MANAGEMENT
ENGINEERING

MANAGEMENT ENGINEERING

THE DESIGN AND ORGANIZATION OF INDUSTRIAL PLANTS

BY

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PREFACE

This small book is the result of an attempt to bring together material which has been treated in many separate volumes. The aim is to make this material available in the classroom, rather than to present new facts or distinctive ideas. Material has been taken from many books, and in so doing it has been the intention to give credit to the several authors by specific mention in each case. If by any chance this has been overlooked, the author takes this opportunity to make due acknowledgement.

There is a growing feeling among engineering educators in the country at large that engineering curricula should include work in economics, pure and applied. It is well-nigh universal practice to send students to the several departments of economics for the fundamental course in the elements. Beyond this the standard courses in economics are specialized to such extent that an impossible amount of time would be required to give an engineering student an introduction to all of the various subjects of which he should have some knowledge. Such topics are brought together in this volume, with brief treatment, it is true, with the purpose of introducing the student to the main principles which underlie business procedure, and of giving him an introduction to more extended specialized treatises.

A mechanical or industrial engineering student has an especially urgent need for a book of this sort. The former educational practice of concentrating the technical training in mechanical engineering into the lines of power development and machine design is giving way to the plan of so directing the training that there will be afforded many points of contact with manufacturing industries. The design and layout of factories are demanding more of the time and energy of the engineer today than is the design of steam engines. Economy in production, on which the industrial future of this country will depend, is something that is directly associated with the layout of industrial plants and the effective control of material as it flows from the stock bins to the shipping platform, and of labor in its manipulative work.

Further than this, there is a science of location of industries. The engineer of the future will exercise more and more fully the function of an industrial expert who analyzes conditions with respect to their influence on industrial establishments. While primarily a man of production, he must have an understanding of the market and its reflex effect upon successful manufacturing enterprises. He must have an appreciative understanding of the influence of transportation on his proposed plan. He must be aware of the fact that climatic conditions and the racial characteristics of the different groups which make up our population have their due share of influence toward success or failure.

It is the aim of Part I to present such an outline to guide the study of the prospective mechanical and industrial engineer. Part II covers the more general problems of organization and administration, adapted to the needs of all classes of engineers. The important topic of contracts is merely outlined in Appendix C. It is given, not as a topic in management engineering, but rather as an accompanying reference to a subject that should be studied with care by every engineer.

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CHAPTER I

BASIC PRINCIPLES

Modern conditions have brought into organized industry a demand for systematic coördination of all the factors which bear upon it. Industrial history recounts the efforts of individuals who have striven, with varying success, to perfect and advance the several phases of production and of marketing. Great advances were made by the introduction of mechanical power. Equipment made usable by power has been developed to a degree almost beyond the imagination. The organization of industry into large interests for the purpose of realizing on the benefits coming from aggregations of capital has been carried far in many lines of work. The legal phases of the organization of companies having the power of attracting capital have received due attention. Transportation agencies have extended their lines to serve industrial enterprise, mainly under the direction of men who have had little to do with production itself. The great business of the distribution and marketing of goods has had its growth under the direction of persons whose interests are purely in that line. These several agents have built well, frequently in conjunction with one another and occasionally in coöperation, but mainly under a system where each considered only his own problems.

It is not to be supposed that this condition will be materially changed, so far as the active conduct of affairs goes. It is true that many of our larger manufacturers sell directly to the consumer, thus combining two of the functions of industry, but this practice is limited to certain classes of products that make up the minority. Economic distribution will continue to call for specialized practices, quite distinct from the practices most effective in production, for the mass of goods turned out by organized enterprise. Actual combination of interests in an organic way is not the point at issue. But with the application of human energy

and wisdom, as these forces must be applied for best effect today, there is the need for coördination and, especially for a sympathetic understanding of the related problems. Producers in particular have need for accurate knowledge of the methods to be employed in selling, and of the needs and peculiarities of their markets. The hit-or-miss method of organizing and building up producing plants belongs to the past. The studied and fully rounded-out plan for dealing with manufacturing enterprises is the distinguishing mark of the present and the future.

Today two separate phases of this general field of activity are recognized, namely—

1. *Correct designing of plants both as to location and physical characteristics.*

2. *Effective operation.*

In sequence of development, the second of these phases of activity came first. Some twenty years ago it was demonstrated by several men that system and scientific methods applied to shop and factory problems would yield results. The work of F. W. Taylor stands out prominently in this connection, and his paper before the American Society of Mechanical Engineers in 1901 was the signal for the beginning of a new era. Important as was that paper in its relation to personnel control, its greatest value lies in the fact that it pointed the way to better methods of dealing with all types of production processes. It demonstrated that the exact methods of the scientist are applicable in industry. As work in this line advanced, it at once became clear that existing factories were not arranged in a manner suited to operating possibilities. Many changes were necessary, some with respect to the handling and routing of materials in process and some with respect to the comfort and efficiency of workers. Thus grew up the activity that has gradually assumed the standing of a separate phase of engineering work, namely, the designing and construction of industrial plants. This deals primarily with new enterprises, or re-established plants of older concerns, and with the consideration of the internal problems of the operating staff there arise questions of proper and desirable locations. Thus the first of the above-mentioned phases of our subject grew into tangible form, under the stimulus of the second.

Closely related to the task of adjusting the physical plant to market demands, selling methods, strategic location, and internal processing are the problems of financing and organizing the

company. It is impossible to plan the physical layout of the buildings, rooms, process equipment, and facilities for handling materials without an adequate knowledge of the operating organization. The technical adviser who is laying the foundation for the success of the enterprise must have an adequate understanding of these matters, even if he does not hold the controlling hand in all. The branch of engineering which has been thus evolving gradually, covering both of these main divisions of activity—plant design and operation—has found need for a descriptive name. One which has been gaining in favor, and which has been adopted in this book, is that of "Management Engineering."

Management engineering is a term coming into more general use to describe the activities of developing and operating producing plants. While frequently thought of as being the same as industrial engineering, it reaches beyond the direct problems of production and process, into the field of administration.

Men of technical training and experience are coming more and more into positions where questions of financial policy and company organization are decided. They are applying to questions of business the methods of analysis characteristic of engineering practice. Their judgment is tempered by knowledge of the facts of process and operating technique. Their work is a blend of that of the mechanical engineer and that of the business man, with the first taking priority as the more fundamental. This fact justifies classing the service as a branch of engineering. The principles of business and finance are adapted, as the principles of physics and chemistry are adapted in the ordinary practice of technical engineering.

Production is a term which, by a sort of common consent, has been employed to designate manufacturing in organized enterprises, according to the custom among the industries themselves. The economist observes no such limitation of terms. It will be used in this restricted sense in this work, although in the discussion of organization and kindred topics railroads will be included as enterprises producing ton-miles and passenger-miles. Fundamentally, the same basic principles prevail in these, as well as in mining enterprises. The test comes on the point of process and equipment. Wherever methods are based on a technique that is dependent on materials the physical characteristics of which are under control, and on process equipment of such a character that engineering principles are involved, then produc-

tion under organized industrial methods may be said to prevail. Ever pressing for the best answers are the three questions of *what*, *where* and *how* to produce under the existent conditions.

Production engineer, production manager, and industrial engineer are three titles having similar meanings but with slight differences of some significance, all coming within the scope of *management engineering*. The first two relate exclusively to operating activities in established plants. The third may apply to work of that same character, or to the design and construction of plants as a business in itself. While exact definitions are not necessary from the standpoint of general business, it is necessary to have an understanding of the meaning to be attached to these terms as they may be used in future discussions on organization and personnel control. Such pseudo-titles as "efficiency engineer" should not be recognized. Every man working anywhere in the entire range of engineering practice is as much concerned with efficiency as is he who happens to be doing the special things that gave rise to that unfortunate term.

DEVELOPMENT OF MANUFACTURES

In briefest outline, we need to sketch the history of the manufacturing industries, in order that a view of certain fundamental factors may be gained. Of these factors transportation has a peculiar significance. In the period when means for transport were few and crude, it controlled in well-nigh absolute manner the concentrations of populations and of industrial capital, following which it will be seen that with its developing agencies it gradually became the means for decentralization.

Early manufacturing establishments, as industry drew away from the domestic period conditions, were centered in seaport towns, because water transportation was the only kind available. For the same reasons, all towns of large size were coast and river towns. In no other way could large quantities of stores or materials for the support of people and of manufacturing plants be moved. Of course, many flour and grist mills, as well as lumber mills, were scattered through areas yielding the raw materials, but even in these lines the plants were mainly on the rivers, so that lumber, especially, could be floated to the seaports. It was simply a matter of whether raw material or finished product could be shipped the more easily. In activities like that of

spinning and weaving woolen goods, where the wool or the goods could be transported with about equal facility, the determining element may have been that of convenience in moving equipment to the mill, this equipment being bulky and heavy. The concentration of workers in the coast and river towns tended in the same direction. Such conditions explain the early development of many of the present industrial centers of the United States. The start thus made gave these towns reputation and prestige, as well as trained workers with acquired characteristics, which became important factors in a continued development on a scale that would not have resulted had more modern transportation agencies been in use from the beginning.

Under the early conditions an extensive maritime trade developed, both domestic and foreign. When the railroads came into existence, they found these established trade routes between the important cities, and, to secure any business, they were forced to adjust their rates, for those towns, to a level lower than they could afford to maintain on the average. This meant that other traffic, not in competition with water routes, was compelled to accept high rates. Out of the situation thus instituted there has evolved a rate-making system, based on arbitrary rulings, which is not in accord with either distance or cost of service. Although rates have been modified in many details through a gradual process of readjustment, the old established centers still enjoy advantages that hold many industries which otherwise would be located in closer accord to fundamental conditioning factors. Rates are fixed on certain base points, usually coast or river towns, and other localities are forced to accept differentials sometimes out of proportion with service demands. The way out of this is slow and perhaps impossible of full realization. The situation is one that must be taken into account in any consideration of the localization of industries.

After the advent of the railroads, the growth of the iron and steel industry was the most striking event in American business. Material resources account for the concentration in the Pittsburgh district. Iron smelting, in common with the smelting of other metals in general, involves two major materials, ore and fuel, and economy demands that only one should be subject to long-distance movement to the point of application. With a major industry thus established, itself the origin of an article which is a raw material for a host of other enterprises, we see

another strong influence made operative. This is the influence of related industries. It comes partly from similarity in labor demands and partly from like trade demands. Marketing is made easier when many related lines of goods are handled from one point. These facts explain the growth that took place in western Pennsylvania and New York, and in the three or four states to the westward, during the latter half of the nineteenth century. Great Lakes traffic helped it on, and it must be remembered also that this section was in the center of the country with a vast undeveloped area, rich in food-producing power, on the western side.

Another type of enterprise, one which must stay close to the source of its principal raw material, was developing at the same time. This was the ceramic industry in Ohio. Related to it—in reality a branch activity—was cement manufacturing in eastern Pennsylvania and, in lesser degree, also in Ohio. Clay products form today a resource common to many sections of the country, awaiting only market demand for development in significant measure.

An important movement of the past quarter century has been that of the cotton-goods industry into the cotton-growing states of the South. The controlling inducements were the water-power resources of the new region and the chance to cut across the long shipping route and reach developing markets without the long haul into the extreme northeastern states and then back to the westward. It has been a step in which the newer means of transportation are used in overcoming the handicap represented by prestige fostered by the older.

There has been a somewhat similar movement in shoe and other leather-goods manufacturing toward the markets of the West. This is purely the effect of markets and transportation. Raw materials are available on about equal terms throughout the country, unlike the situation in cotton goods, and the cost of shipping the finished article to market has been the determining factor. St. Louis became an important shoe city many years ago, and now the business is moving still farther west.

A different set of conditions led to the growth of the agricultural implement business in the Mississippi Valley states. As agriculture on the level plains of the West was built up, new types of machinery and implements were demanded, thus creating a market distinctly regional. Transportation in the finished

state is expensive for such articles, so that manufacturers in the near-by centers had several points of advantage.

Still another industry in which transportation casts the deciding vote is that of petroleum refining for the volatile fuel products. No particular grouping is noticeable. The light products, especially gasoline, are transported only at considerable cost and some danger, while pipe lines furnish the means for moving crude oil economically. The result is the placing of refineries at important marketing centers. The opening of new producing fields in various parts of the country has caused a wide spread of the refining business as a whole. The date of the beginning of oil refining was so late, however, that it has prevented the building up of any center of activity in such a degree as to amount to concentration in any one section of the country.

In considering the extent of growth of the industries for our present purposes, values of products form an unsafe guide. The value of the dollar has varied so greatly that it does not serve as an index of the true influence of the several activities as factors in social and economic progress. A more significant, because more constant, element is the number of persons engaged. While it is true that the product per employee has steadily increased, there has been a measure of uniformity in the increase. After all, it really is the influence on population rather than the amount of goods produced that is of significance, and, for this, the number of persons employed is the direct index.

The following tabulations and graphs show how some of the more important industries have developed over a long period of years. For some of them it has been possible to trace the growth in the several groups of states, and thus to portray the gradual westward movement that has taken place.

In the aggregate, the sum total of the manufacturing industries, combined with the railroads and coal mining closely related thereto, constitutes the means of livlihood of a large portion of the population of the country. In the last few decades the United States has become an industrial nation. While exports of raw food products, cotton, and a few other commodities continue, we have developed as a market for these same commodities, so that imports in various lines are coming in, and our exports have changed gradually to include finished manufactured goods in many lines. The present status is one of mixed interests, more difficult to deal with successfully in the adjustment of trade

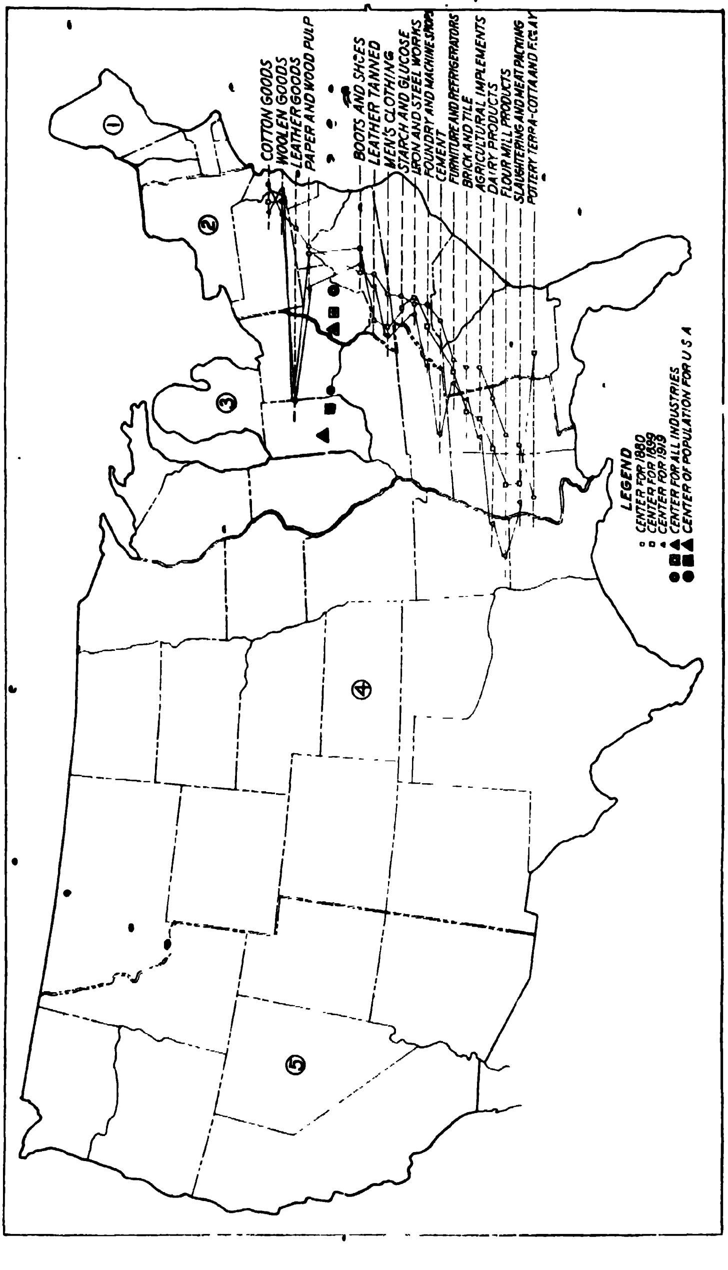

FIG. 1.—Map showing westward trend of industries.

TOTAL FOR THE UNITED STATES—NUMBER OF PERSONS ENGAGED IN THE FOLLOWING INDUSTRIES

Industry	1919	1914	1909	1904	1899	1890	1880
Agricultural implements	67,177	58,118	60,229	55,089	57,254	42,544	39,580
Beet sugar	14,190	9,634	8,389	4,726			
Boots and shoes, including cut stock and findings	259,234	227,605	215,923	171,940	161,579	148,827	115,972
Brick and tile	86,503(a)	110,772(a)	85,764	75,006	71,057	109,151	66,355
Cement	30,247	31,958	29,511	18,88[illegible]	(b)	13,710	5,669(c)
Cotton goods, including cotton small wares	....	...	387,771	323,287	308,237	221,585	185,472
Dairy products, butter, cheese, and condensed milk	49,865	34,795	31,506	25,865	22,604	14,921	7,903
Flour mill and grist mill products	75,769	65,635	66,054	59,623	49,748	63,481	58,407
Foundry and machine shop products	577,308	429,072	615,485	502,185	470,271	247,754	145,351
Furniture and refrigerators	......		144,140	125,093	99,336	16,210	11,628
Iron and steel, blast furnaces	46,956	33,194	43,061	37,335	41,046	(b)	(b)
Iron and steel works and rolling mills	421,861	274,162	260,762	221,956	190,825	193,557	157,595
Leather, tanned, curried, and finished	79,292	60,780	67,100	61,602	56,024	34,348	34,865
Leather goods	47,736	45,161	47,895	40,508	34,481	3,074	1,036
Men's clothing, including shirts	.....	....	271,437	196,366	174,455	24[illegible],857(d)	160,813
Paper and wood pulp	124,935	95,516	81,473	70,051	53,012	32,398	25,631
Pottery, terra cotta, and fireclay products	30,692(e)	28,758	61,022	56,730	47,435	20,296	10,221
Slaughtering and meat packing	197,392	121,729	108,716	88,819	80,581	49,052	27,297
Starch and glucose	8,694	5,957	5,827	5,679	5,079	4,880	4,311
Sugar refining	20,921	12,561					
Woolen goods, worsted and felt goods, and wool hats	......	......	175,176	152,306	135,505	79,351	86,504

(a) Includes terra cotta and other fireclay products.
(b) No figures given.
(c) Includes lime and cement.
(d) Includes custom work.
(e) Pottery only

NUMBER OF WAGE EARNERS EMPLOYED IN TYPICAL INDUSTRIES

Industry	*Group of states	1880	1890	1899	1904	1909	1914	1919
Agricultural implements	1	2,644	1,820	870	916	949	311	241
	2	10,884	9,344	9,115	11,313	10,918	8,526	7,371
	3	22,650	28,073	42,743	37,081	42,392	34,814	41,674
	4	301	2,581	2,560	3,490	3,626	2,340	1,790
	5	329	693	655	585	749	838	1,724
Boots and shoes, including cut stock and findings	1	33,940	83,274	90,137	93,407	112,939	109,482	116,400
	2	26,468	32,961	36,959	36,928	45,090	45,404	53,426
	3	10,153	14,515	24,307	26,611	34,185	29,720	32,987
	4	918	1,226	9,551	13,807	22,703	17,402	22,641
	5	3,326	3,269	1,151	817	840	795	762
Brick and tile	1	4,640	7,021	2,916	2,328	1,957	812(2)	423(2)
(2) Include pottery, terra cotta, and other fine-clay products.	2	25,979	40,340	25,040	25,917	30,513	52,261(2)	42,976(2)
	3	23,704	36,892	25,049	26,641	28,650	50,650(2)	41,748(2)
	4	10,666	14,975	13,104	14,772	17,091	14,941(2)	13,204(2)
	5	1,264	4,043	1,908	2,897	4,745	4,338(2)	3,211(2)
Cement	1	10	961(a)	(x)	(x)	(x)	(x)	(x)
(a) Cement and lime	2	650	5,669(a)	(x)	10,862	12,091	10,193	9,017
(x) No figures shown	3	401	4,669(a)	(x)	3,426	6,595	6,010	5,118
(c) California, Washington, and Utah.	4	15	1,673(a)	(x)	776(1)	2,365(1)	1,585(3)	1,725(3)
(1) Kansas only	5	13	519(a)	(x)	628(2)	2,521(2)	3,307(c)	2,032(c)
(2) California only.								
(3) Kansas and Texas								
Cotton goods, including cotton small wares	1	128,948	148,748	166,054	161,769	192,348	195,003	211,118
(x) No figures listed.	2	45,160	61,827	121,170	138,264	167,874	171,765	199,137
(1) Texas only.	3	5,735	8,739	15,189	19,139	23,009	21,208	27,367
	4	764	(x)	1,005(1)	1,029(1)	1,633(1)	1,875(1)	2,633(1)
	5	(x)	29	(x)	(x)	(x)	(x)	(x)
Dairy products, butter, cheese, and condensed milk	1	303	814	1,624	1,147	1,165	666	739
	2	3,757	4,303	6,455	7,112	7,160	4,807	7,286
	3	2,333	5,020	7,760	9,294	13,280	9,160	14,088
	4	999	4,621	5,099	5,762	6,550	5,482	8,036
	5	480	118	1,346	2,000	3,955	2,722	4,373
Flour mill and grist mill products	1	1,487	2,488	1,948	1,950	1,945	903	628
	2	18,664	19,086	11,624	15,233	16,202	9,081	8,468
	3	22,218	23,334	17,148	20,282	21,296	12,645	12,887
	4	13,923	16,707	15,153	18,951	22,988	14,192	18,711
	5	1,481	1,905	2,809	3,307	3,623	2,897	4,787
Foundry and machine shop products	1	30,905	46,267	84,154	89,296	111,561	98,852	145,112
(a) No figures reported for Pennsylvania or Virginia.	2	70,894	106,866	106,555(a)	202,481	228,092	206,690	278,246
	3	33,356	73,245	118,056	171,792	225,079	212,961	355,494
	4	8,401	16,654	15,974	26,557	35,487	31,703	59,153
	5	2,794	4,716	7,931	10,777	14,877	13,820	32,454
Furniture and refrigerators	1	6,432	5,135	8,641	9,321	10,484	9,628	8,946
	2	18,923	21,471	30,732	39,923	47,969	47,508	49,179
	3	21,761	33,368	51,030	64,304	71,687	61,706	66,973

	4	3,672	4,467	6,260	7,868	9,793	8,008	8,839
	5	1,243	1,276	1,259	2,222	3,275	2,837	4,639
Iron and steel works and rolling mills	1	11,324	5,824	6,192	4,939	3,465	5,107	7,072
(1) Missouri only.	2	90,827	118,856	117,552	141,787	159,980	153,548	216,066
(2) California only.	3	44,464	47,957	55,333	60,080	80,550	77,645	121,840
	4	4,758	1,207	1,656(1)	1,410(1)	2,379(1)	1,237(1)	2,647(1)
	5	633	969	573(2)	808(2)	1,085(2)	1,244(2)	3,476(2)
Leather, tanned, curried and finished.	1	10,202	7,846	8,379	10,521	11,787	11,159	16,363
(1) Missouri only.	2	20,513	16,528	31,473	33,636	35,735	28,432	35,643
	3	6,998	8,178	13,181	14,289	17,277	13,959	17,345
	4	399	506	209(1)	242(1)	246(1)	277(1)	265(1)
	5	944	1,262	1,654	1,479	1,605	1,395	1,492
Leather goods	1	62	311	2,135	2,855	3,116	1,615	1,848
(x) Not listed.	2	974	2,234	14,412	17,655	17,880	14,330	15,167
	3	(x)	313	10,619	11,732	12,942	7,811	8,100
	4	(x)	27	5,032	6,008	7,063	3,765	5,182
	5	(x)	(x)	1,431	1,585	1,832	1,050	1,115
Men's clothing, including shirts	1	16,200	15,806	9,175	9,994	12,109	11,326	11,019
(a) No figures shown for Indiana or Mississippi.	2	101,337	85,454	103,599	118,090	164,792	132,236	120,614
(2) California only.	3	35,061	41,743	38,411	50,774	73,207	61,671	61,791
	4	6,378	12,976	14,034	12,698	16,253	14,003	15,611
	5	1,862	4,592	3,537	3,756	3,748	2,468(2)	2,941(2)
Paper and wood pulp	1	11,126	11,353	20,047	26,306	29,609	30,501	34,849
(x) Not listed.	2	8,273	9,871	18,604	24,610	26,809	28,413	35,520
	3	5,091	7,058	12,597	16,729	20,600	23,773	33,294
	4	45	129	193	688	974	1,671	2,950
	5	201	(x)	(x)	273	340	(x)	(x)
Pottery, terra cotta, and fireclay products	1	22	1,004	682	644	541	(x)	(x)
(x) No figures listed . .	2	150	8,906	23,461	25,522	26,561	(2)	(2)
(2) Included in brick and tile .	3	194	7,485	17,961	24,011	25,859	(2)	(2)
	4	77	1,919	2,788	3,732	4,727	(2)	(2)
	5	75	477	643	1,165	1,593	(2)	(2)
Slaughtering and meat packing	1	1,956	2,324	3,964	4,374	4,811	3,973	5,088
	2	3,243	4,393	8,151	9,888	16,264	14,806	19,120
	3	16,615	22,303	41,501	41,987	45,570	43,707	72,955
	4	4,983	10,912	24,961	29,521	37,646	32,184	55,930
	5	524	377	1,792	2,415	3,749	3,836	6,226
Starch and glucose. .	1	395(a)	441(a)	174	202	195	114(d)	255(d)
(a) Starch only.	2	2,280	1,247(a)	(x)	(x)	(x)	(x)	(x)
(x) Not listed.	3	1,562	1,960	219(c)	510(c)	955(c)	(x)	(x)
(c) Indiana only.	4	72	211(a)	(x)	(x)	(x)	(x)	(x)
(d) Maine only.	5	(x)	(x)	(x)	(x)	(x)	(x)	(x)
Woolen goods, worsted, felt goods, and wool hats. .	1	52,037	52,868	77,021	93,334	110,488	104,106	110,191
(1) Minnesota only.	2	31,914	40,624	44,291	46,177	54,101	48,708	49,586
	3	6,762	9,448	7,128	7,643	8,462	3,735	4,761
	4	1,667	1,619	619	654	454	448(1)	574(1)
	5	522	676	508	594	508	648	808

*Groups of States: 1, New England; 2, Atlantic Coast to Appalachian Mountains; 3, Appalachians to Mississippi River; 4, Mississippi River to Rocky Mountains; 5, Rocky Mountains to Pacific Coast.

relations than was the case when imports were almost wholly manufactured articles and the aim was to stimulate home industries by protecting them from foreign competition. For the maintenance of trade in the markets of the world, on which the present system depends, there exists the necessity of holding down costs of production. Some of the conditions peculiar to this country tend to increase costs, notably high wage scales to accord to living standards. To offset this, other cost elements must be reduced, mainly through improved design and efficient methods. It is this necessity which has brought about the highly developed systems which characterize American industry, and out of which this new phase of technical activity known as *Management Engineering* has grown.

We thus come to a consideration of this thing which is termed the *Factory System*. We need to analyze the true elements which form the basis for the present methods of doing business in the producing industries. Superficial statements do not suffice. In order to understand the plan of organization, construction, and operation of a modern enterprise, or to forecast the conditions for such, we must get at the underlying principles. To do this it is necessary to go back of the physical and look at the fundamental economic principles which underlie production.

THE FACTORY SYSTEM

Consciously or unconsciously, as modern industrial methods developed, it became recognized, on the one hand, that the populations which constitute the markets of the world were intensely concerned with the conditions surrounding the production of manufactured goods, and, on the other hand, that producers, in their need for permanent and steady markets, must consider with care the demands and needs of those markets. Exceptions and monopolistic ventures to the contrary notwithstanding, the history of manufacturing has been that of the growing needs and capacities of consumers, with the progressive manufacturers ever studying and anticipating those needs and usually making possible the notable advances in the arts of civilization.

In the early years producer and consumer were close together. This was true in the geographic sense, with the limited transportation facilities, but in a more significant sense it was true

with respect to methods and aims in production. Even after machinery came into service and adequately equipped factory buildings became the rule, at least in a few industries, workers were still in relatively close touch with consumers. Too frequently, perhaps, we allow our judgments to be formed by conditions in the cotton and woolen goods branches of the textile industry. It is true that in those two lines development to something near present-day conditions took place rapidly. In the far greater number of manufacturing activities, producing workers remained in touch with consumers and their needs well on toward the later decades of the nineteenth century. Specialization had not become pronounced in most lines, and each worker had to do with the product as it assumed the form in which it was destined to serve the consumer. His part in it was specific and apparent, and he could not escape a personal responsibility for quality. The incentive for him was to produce an article having tangible qualities associated with the ultimate consumer whose existence was real.

As development proceeded in one industry after another, the physical equipment increased in many respects and in ways which we need not attempt to analyze. But machinery of the physical process variety did not bring about the vital change. The fact of having mechanical power derived from steam or other motor did not. Even with all the physical appliances, and in large buildings, many workers might have continued to produce with the same direct contact with the finished article and with the needs of the consumer. The vital element of the new system with respect to the individual worker is that he no longer has that contact. He is now working on the production of articles, or parts of articles, or is assembling parts which others have made. He no longer produces the article having real working qualities, but an article conforming to specified standards. His incentive to effort is different from the former one. It may be made as real an incentive, although different, *but that depends upon the management*, not upon the needs or demands of the consumer. The contact between producer and consumer, through which the aim of production is realized, is by delegated agents. It is action in *mass*.

Some may say that this change in the status of the worker is the effect only of the factory system. It is more than effect; it is the significant factor in the system. Not physical equipment in

itself, but organization of the plant and staff, management of operating details, and determination of character of product are the vital elements. The worker is the vital force at the last analysis, and the others are agencies through which his efforts are made effective and coördinated with all other forces. The system is the result.

This is the point to which we have grown in but little over a century of progress. There are many real problems to be solved by those who are to control further advancement, some of them human problems and some of them physical. It is a challenge to the technical man, who must bear the brunt of the task.

FACTORS DETERMINING LOCATION OF INDUSTRIES

In the preceding sketch of the development of manufacturing activities, mention has been made of certain influences which have led to the building up of centers. Especially has it been noted that transportation agencies have controlled in marked degree. Further discussion of that factor is unnecessary, except with respect to the reference there made to the effect that the railroads have become a decentralizing agent. In this view of the present situation there should be included with the railroads the other means of communication as well as local transportation appliances. The telephone and the automobile have acted with the steam roads to change the conditions of living in small towns and rural districts. Marketing is a different proposition from what it was a few decades ago. Demands for goods are more uniform in all parts of the country. There is a new social system as well as a new factory system—an effect that cannot be overlooked.

A well-known authority on the scientific location of railroads, A. M. Wellington, has called attention to the fact that true economy is secured when the combined cost of production and transportation is a minimum. In the early days of railroad building this meant opening up undeveloped regions, the raw products from which could be carried in quantities to the centers of population where demand was largely localized. Those centers coincided mainly with manufacturing centers, for reasons cited in the preceding section. But the areas thus opened have built up rapidly in population—the purchasing power and tastes of these people being similar to those in the eastern cities. This

called for return shipments of goods in finished form, of types more expensive to transport than the raw materials which were moving east. The cost of handling was greater and the kind of freight cars required was different from the kind used for cattle, grain, and ore. Return shipments in kind were not forthcoming, so that long trains of "empties" have been familiar sights on our roads in both directions. Furthermore, much of the raw material for the finished goods moving west could be moved more cheaply than could the goods themselves, constituting a motive for placing more manufacturing nearer the growing communities of the West. Thus started the westward stream of iron, coke, leather, and baled textiles, there to be converted into goods for the market; while in similar measure cattle, wheat, corn, and ores were stopped in their eastward movement for manufacture at intermediate points. Thus decentralization was begun.

One of the best illustrations of this process is afforded in the decision to establish a steel plant in the Duluth iron ore district, in this case the lake steamship lines acting in the place of the railroad. Fuel, the raw material parallel to ore in the iron blast furnace process, can be moved from the Pennsylvania fields to Duluth in the same boats that bring ore to the Pittsburgh furnaces, reducing the extent to which those boats must return in ballast. The steel produced at the new plant is destined for the trade of the Northwest.

The trend of adjustments in freight rates is toward the same result. A gradual breaking down of the rate system favoring the older established industrial centers is apparent. It may not be clear as yet what the final rate system will be, but one may venture the opinion that the trend is toward a combination of railway terminal and transfer charges, and distance of actual shipment. In several recent decisions of the Interstate Commerce Commission the consideration of length of haul has been apparent. Because of the necessity of moving certain commodities in bulk for long distances, under the conditions existing in a country of large extent like the United States, where different sections have their own natural products that must move at low cost to population centers, it is not possible to change to a system based strictly on cost of service. However, in respect to the same commodity, moved over varying distances in different parts of the country, there would seem to be good reason for taking account of the item of distance in a more specific way

than has been done in the past. As the process of adjustment along this line continues there will be an increased incentive toward production of articles in their final marketing form at points favorable to distribution, especially when the materials employed move over the long hauls at lower rates.

It is a recognized fact that in this country we have been prodigal in regard to transportation. On the ton-mileage basis the amount per capita is higher than is necessary. This is due in part to accidents of climate and topography, but mainly to an unscientific distribution of industries. The Wellington principle of minimum combined cost of production and transportation is not being realized, even with the freight rate question in its present status. The result is unnecessary congestion of traffic at certain seasons, and shortage of rolling stock at other times. The cause is not so much the railroads in themselves as it is the lack of a true industrial system. The remedy, when once applied, will have further decentralization of industry as one of its elements.

Raw materials bind certain industries to locations at points at or near the source. It is impossible to conceive of plants engaged in the production of cement, brick, tile, and other ceramic commodities, located far from deposits of limestone, shales, and clays.

Sometimes it is a secondary process material, such as fuel, that is the localizing factor. Process and the relative costs of transportation must be analyzed in settling the question as to which factor prevails. Again, it may be a combination of material and power resources, as in the cases of the large pulp paper enterprises which have been pushed back into the forests of the North on streams affording water power. For all such, economy in production is the controlling consideration.

The market is followed closely by another group of industries. For such it will be observed that the product is of a kind expensive to transport, whereas the raw materials ship readily on a low rate classification. Shoes and other leather goods are illustrations, as are certain kinds of metal manufactures. The combination of transport facilities and market is exhibited clearly in the instance of the Standard Oil Company, whose refineries handling Mid-Continent crude oil are distributed along its pipe line at such marketing centers as Kansas City, St. Louis, and Chicago (Whiting).

Climatic conditions constitute another controlling influence. A case in point is the humid atmosphere of England and of the Atlantic Coast states in its effect on the textile industry, sometimes combined with cheap water power, as applied to the high-powered cotton spinning and weaving processes. While it is possible to control artificially such a thing as the moisture content of the atmosphere within a plant, so that textile manufacturers need not always cling to a given region should other factors become prominent, still a natural condition such as this constitutes a marked advantage.

Labor conditions determine in large measure the location of a wide variety of activities. Whatever may have been the original causes, development in a region will give rise to a type of population that is adapted to service in that kind of factory. Sometimes such adaptability of population is based on mental or social traits, sometimes on acquired skill, sometimes on nationality. The class of work called for has a relation to this situation, and it must be recognized by the successful manager. In many respects this is the most compelling of all the influences that operate to determine the location of the more general types of industries. He who locates his enterprise in opposition to it must expect to spend both capital and time in creating an environment.

In the industrial field one frequently meets cases of successful enterprises that seemingly violate all of the established precedents. One sometimes wonders how a plant ever happened in such a location. Such instances form a sort of oasis in a desert of dry formalism. Usually they are explained as the results of personality and determination of individuals who have seen fit to go into business and have stuck to it. Sometimes they are pure accidents. But if the really successful ones are carefully analyzed it is likely that a good reason for success will be found, and very commonly this reason exists in the form of a marketing situation that many have failed to appreciate. It is such a circumstance as this that gives encouragement to those who look forward to a more general development of manufacturing in all parts of the country. It will require close and accurate examination of the controlling factors, and then some courage. There is need of the developed mind, however, to insure that foolhardiness be not mistaken for courage.

In every location problem there must be made an *intelligent analysis* of the situation. The industrial expert can afford to

neglect nothing. Seemingly small things may tip the balance for this or for that location. The changing conditions of transportation are leading to new developments. Rates on many commodities will never return to the old levels, and shifts in producing centers will result. The changing of basing points in our artificial system of adjusting freight tariffs would mean many industrial readjustments. The increasing significance of the food-producing power of the soil—the increasing burden on transportation coming from the need of carrying food to ever growing centers of population—all such matters are destined to bring about changes. The production engineer or manager cannot live to himself in his plant. Production is linked up with all these other elements. To know *what*, *where*, and *how* to produce is the full problem, and there are many variables and some unknowns involved in the solution.

PRODUCTION FACTORS

We may now group together the several factors which have direct influence on the problem of production. In any analysis of conditions which bear upon the question which confronts anyone contemplating the starting of an enterprise, certain things must be settled. Some pertain to local matters and some are inherent in the nature of the business. To assure success, there must be found the best combination, which means compromise on some points in most cases. Knowledge of conditions in the territory and careful study are necessary. Under the following seven heads may be grouped these conditioning factors:

1. Market.
2. Capital.
3. Materials.
4. Process, involving equipment.
5. Labor.
6. Power, availability and cost.
7. Transportation facilities.

Previous discussion has borne mainly on the question of location. It has been seen that each of these factors has a bearing on that, unless there be excepted capital and process. Even on these, local conditions may have some bearing. Banking houses may be friendly or unfriendly. As to process, such a matter as

water supply, both as to quality and quantity, may be of significance. Hence it may well happen that every one of the seven factors has its part in the selection of the most favorable location.

For economy in production, the same statement may be made. The scale on which the business is to be conducted has a direct influence, and the extent of market demands and of available capital has weight in determining this. Many an enterprise has found its way into the bankruptcy court because marketing conditions were not correctly estimated at the start, and many others have gone the same way because of insufficient capital. They are business matters which some continue to think of as non-technical, but they are so closely bound up with the technique of production that separation is impossible. It is a distinguishing mark of the new order of things when production experts show ability to deal intelligently with them.

The significance of these factors does not end when questions of location and finance are settled. They figure prominently in the design of the plant and in forming the operating organization. Every establishment has its own peculiar setting, calling for specialized treatment based on the properties of materials, it may be, or, in other cases, where standard materials are employed, based on the form of power resources as affecting types of equipment and its arrangement in the plant. Such variations make the task of designing industrial plants one which is alive with interesting problems and which presents opportunities for the most talented to exercise their powers. The selection of power equipment depends upon local conditions. Climate influences the need for heat, sometimes tipping the scales in favor of, or against, the choice of steam power generators in comparison with internal combustion engines or purchased electric power. Water supply may decide the question between condensing and non-condensing engines. Prevailing atmospheric conditions may necessitate air washing and humidifying, or call for special care in the protection of employees. These, and many other elements, call for true plant designing as a condition for making economic production possible.

Finally, in the operation of the plant the working organization is influenced by these factors. Conditions in the marketing area will determine methods of selling and so react on the sales force. The types of available labor will determine the emphasis to be given to training and to welfare activities. If the location is in

a remote district affording little in the way of homes and social advantages, the problem has many aspects different from those in larger towns. The executive staff must be selected with such matters in view. Policies as to the use of surplus funds, building up of the plant, and reserves for depreciation and amortization depend upon such matters as growth of market, permanency of supply of materials, or continued productivity of the soil where the business depends upon farm products, all of which influence the probable life of the enterprise.

Operation is removed in certain respects from the earlier phases of the design and establishment of the enterprise. Given the plant, the internal factors govern. Successful administration consists in the effective control of those factors which represent the physical and human forces acting under the imposed conditions. How this control has developed into forms characteristic of modern industry is the subject of the next section.

DEVELOPMENT OF THE ADMINISTRATIVE FUNCTIONS

It is important here to observe the functions of the several agencies employed under the general designation of organization and management. It is through these agencies that economic results are obtained and the system maintained. To do this, one may best start with a simple one-man industry of domestic variety and trace its imaginary development to the fully organized plant.

In the early stages of many machine-building companies one man performed all of the several functions. The machine, usually simple, was of his own design; he had built his shop and equipped it from his own or borrowed funds and attended to its upkeep; he selected and ordered the material; he performed the actual work of construction, perhaps with a few assistants who worked under his direct supervision and were personally interested in the finished machine; he kept his accounts himself, calculating costs and profits in the business; he attended to the selling of the product, this being accomplished mainly by the taking of orders from acquaintances or from jobbing houses. He thus held full control over the enterprise through this exercise of the six main functions in the producing activities, this control constituting the seventh function.

With the growth of business it became necessary to add to the working staff, and the other activities absorbed his time more and more fully. The supervision of the workers soon passed to an appointed foreman, and then to a superintendent of production, whence the function of *operation* passed from the direct hand of the owner. This department has taken many forms in various plants, with numerous organized branches to take care of the problems arising in connection with the hiring, directing, and care of labor. With growth and development, specialization became profitable and possible, while the individual worker became more and more widely separated from the finished article as before noted.

As the operating function passed from the direct hand of the owner and the use of the plant became more formalized, problems of equipment increased. Buildings, process machinery, power, heating, lighting, sanitation, and other details demanded constant attention, and in time another department was formed to exercise the function which may be designated as that of *equipment.*

Similarly, the progress of events made necessary the perfection of the product and the devising of new forms for wider application, so that designers with special training and experience were employed. This meant the separation of the function of *design* from the direct duties of the owner. So with the functions of *accounting*, *purchasing*, and *selling*, until the owner and original performer of all vital parts of the work found himself divested of the several burdens of direct responsibility calling for specialization in action, but retaining the one function of *management* or *control* over the business as a whole.

While every enterprise may not have an organization which conforms to the exact outline here given in respect to the creation of separate departments, all on a common level of authority under the general management, these six are the functions which must be performed effectively in every plant which does business on a scale which warrants a rating in the commercial world. Mere size is not the criterion, but if these elements are recognized and operations made to conform in general to such a plan, then the modern factory system may be said to obtain.

This list of functions to be exercised in the conduct of operations by a producing company is the basis of organization. Enumerating them more nearly in the order of treatment, although not necessarily in the order of importance, they are

management or *control, design, equipment, operation, purchasing* or *material, sales,* and *accounting* or *comparison.* In respect to complexity of the task, as well as in touching the vital element in the factory system, operation is the most significant. During the period of marked advancement in the physical aspects of industry, up to the opening years of the present century, operation was given comparatively little scientific study, but at present its more perfect development constitutes a leading part in the work of the industrial engineer. In the chapter on organization the seven functions will be taken as a basis, and types of development adapted to different branches of industry worked out in detail.

CLASSIFICATION OF INDUSTRIES

Manufactures Classified as to Character of Product.—For many purposes, it is convenient to employ the classification adopted by the United States Census Bureau. Census reports give much data that are of value, even though subject to many errors because of variations in gathering information on the many separate enterprises. The published figures are averages covering a wide range of conditions, and therein lies their significance, as well as an indication of the manner in which they should be used. Attempts to use them in direct application to individual concerns are attended with doubt as to reliability, so that they must not be taken as infallible guides, but when used in a sane and conservative manner as general indications of the conditions under which operations may proceed, they are of service. Such usage presupposes an accompanying study of local conditions.

In Chapter II there is given the result of an analysis of Census data for 50 representative industries, in the form of a table showing relative values of the dominant factors which enter into plant operations. The complete discussion given there makes further comment at this point unnecessary.

Manufactures Classified as to Treatment of Material.—Important differences exist in this regard, their effects being felt in the design of the physical plant in respect to such matters as providing for storage of materials in the raw, partly finished, or finished states; for shipping facilities in and out, and local transportation; arrangement of process equipment; and organization of the

working force. The distinctions are not sharply drawn, but it is of some value to recognize the three following groups:

1. Analytical industries.
2. Synthetical industries.
3. Neutral or conditional industries.

The first type is represented by any business which uses a single raw material to produce an article which possesses properties markedly different from the original, so that the process is not simply one of concentration or separation. Process materials may be employed in various ways, but the product in its final form contains only the one kind of substance, or some part thereof. Naturally, there may be several products derived from a single raw material. Illustrations of this type are found in the simpler textile mills, where the process ends with spinning or simple weaving; meat packing; sugar refining; lumber mills; wire mills; petroleum refining; flour mills; salt manufacturing by the evaporative process; and ice manufacturing.

The second type is represented when two or more materials are treated and combined to form the finished product. This may be done simultaneously, by consecutive steps, or by concurrent treatment of materials which are afterward united or assembled. In the first of these divisions come blast furnaces, paint and many other chemical works, dye works, clay products, glass, cement, canning and preserving, etc. In the second and third divisions, between which it is not always possible to distinguish, and to do which is really unnecessary, come many of the more complex textile industries, including the manufacturing of hats; leather and leather goods of all kinds; paper; and an immense variety of industries in metal and wood, and all conceivable combinations of those materials in salable articles; and including also the erection of structures of all kinds.

In the third group come the industries described as being:

a. Locative, when matter is simply moved, as in the business of transportation companies.

b. Concentrative, when material is separated from impurities, as in the concentrating of ores, rice cleaning and polishing, etc.

c. Purely conditional, as in district heating and refrigerating enterprises.

Industries Grouped as to Dominant Factors.—In the business of producing and marketing manufactured goods, there are two

requisites necessary to success. These are quality of goods and economy in the various processes. All of the many factors which go to make the successful enterprise are but variations or parts of one or the other of these.

Before proceeding to discuss the different elementary factors in detail, it is well to observe that a more or less definite grouping of the different industries may be made, there being in each group a common principle which has developed in practice and which is plainly influential in the attainment of the two essentials – quality and economy. In referring to these essentials the word "design" will be used in the sense of determining the character of the product, or quality, and the three factors, quantity of output, equipment, and operation, all bearing upon economy, will be employed to indicate that requirement. This grouping will thus touch closely the questions of process and of organization and will serve as an introduction to the later sections in which those two factors are dealt with in much greater detail as regards a few selected industries. This brief survey will serve the purpose of bringing attention to certain facts regarding methods and practices in many of the lines of manufacturing, some knowledge of which is essential to an intelligent discussion of the production factors listed in the preceding section. Frequently it is convenient to separate the complete industries into component parts, when the parts represent processes which are carried on independently, often forming distinct enterprises.

The leading factor in this grouping is the character of product, in the sense of quality.

Group 1.—This includes those industries in which character of product is determined almost wholly by the raw material employed, the process doing little to change the fundamental nature of the material. Two subgroups should be recognized:

a. Those in which improved equipment is mainly for the purpose of bettering the quality of the output.

b. Those in which improved equipment is mainly for the purpose of lowering cost.

Naturally, most of these industries are of the analytical type, usually with but a single product coming direct from the single raw material. Equipment is employed always, but it is of a standardized form to suit the comparatively simple process, or else is of a pure labor-saving character for transportation pur-

poses. Operation is emphasized, it being largely the performance of routine duties. Standards of quality are set by superintendent or foreman, either by adjustment of machinery or by occasional sampling and testing of product, and in most cases but little responsibility of this kind rests upon the working operative. As a rule the number of workers is small in proportion to product. The quantity of output depends largely upon the plant considered as a unit, rather than upon the individual worker or individual items of equipment. Great care is necessary in the selection of purchased raw material.

The following industries may be classed in this group:

a. Flour and grist milling, for the standard products.
Cotton, woolen, and silk textile mills, for the processes up to the end of spinning and drawing. Separate plants for the production of yarn are numerous.

b. Slaughtering and meat packing for the standard products.
Lumber mills producing usual stock lumber.
Natural cement plants.
Rice cleaning and polishing plants.
Raw sugar mills.
Salt manufacturing.
Canning and preserving for standard products.

Group 2.—This includes industries in which character of product depends more directly than is true in Group 1 upon the equipment employed. The character of the raw material is not changed in any chemical or fundamental sense, but the product is worked into more complex forms and in most cases two or more raw materials are combined, although these materials may be of the same basic character, as in the case of the warp and filler in the weaving of cloth.

Equipment, of course, is of special importance, affecting both quality and quantity of product. Increased output may be effected by attention to individual equipment units as well as by complete plant development, and this involves the special training of machine operators and other workers. Thus the management functions pertaining to operation and equipment receive attention in about equal measure. The number of workers remains comparatively small in proportion to product.

The following may be classed in this group:

- The more complete textile mills for weaving of cotton, woolen, and silk cloth, including mills for complete treatment of material from raw state.
- Knit goods.
- Cordage and twine plants.
- Carpet and rug weaving.
- Milling of special cereals, breakfast foods, etc.
- Boot and shoe factories, in both leather and rubber.
- Paper bags, boxes, etc., separate from paper mills.
- Wall paper factories.
- Standard forms of hardware and sheet metal, where utensils are formed in presses and stamps, including nail and wire mills.
- Special wood novelties, spool mills, toothpicks, matches, etc.
- Ice manufacturing.
- Concentrating and reducing mills for treatment of metal ores.
- Rubber tires for vehicles.
- Public utilities, including transportation, light and power, and telegraph and telephone.

Group 3.—This includes the great variety of industries in which character of product depends upon the process. Raw materials of proper kinds and qualities are assumed, of course, but, in general, these products are determined by the process, the same materials being susceptible to working into different articles. In most cases extensive equipment is employed, affecting both quality and quantity of output, it being mainly of specialized forms adapted to the process. This last element touches the most significant point of difference between Groups 3 and 4, the latter including those industries in which standard equipment is employed and adapted by the workers to the production of varied articles.

These industries call for staffs of experts and trained workers giving special attention to quality as well as form of product, and also to the specialized equipment. In many cases this special treatment extends to types and form of construction of buildings in order to adapt them to the equipment or to facilitate the movement of material, or both, as is noticeable in sugar refineries and leather tanneries. Hence the organization element of design, in its broadest sense, comes to the front alongside, if

not ahead, of equipment and operation. As a rule the enterprises require large capital investments, and the general function of management or control presents important and comprehensive problems. For most of them, however, the products are few in type, often of a single variety, so that accounting problems as to unit cost of output are comparatively simple. The same is true as to varieties of purchased material, but the quality of that material is an important consideration. The number of workers generally is greater than in the preceding groups, and sociological questions in adjusting the conditions for labor enter into the problem of operation. The training of operatives must bear upon the nature of the product as well as upon the use of equipment, although the proportion of highly skilled workers to the total is not great when compared to Group 4.

The following may be classed in this group, many having a chemical basis:

Meat packing and curing.
Sugar refining.
Confectionery.
Bakery products.
Dairy products.
Glucose and starch.
Leather tanning.
Soap manufacturing.
Liquors and beverages.
Oil refining.
Paper and wood pulp, and special products of the same.
Portland cement.
Brick and tile plants.
Glass manufacturing.
Lime kilns.
Zinc and copper smelting.
Paint and varnish plants.
Turpentine and rosin plants.
Crude rubber plants.
Explosives.
Photographic supplies.
Chemicals, in general.
Blast furnaces.
Foundry products in all metals.
Steel and rolling mills.
Tin plate and tern plate mills.
Hat and cap factories.
Print and dye works.
Oilcloth and linoleum factories.

Group 4.—This includes those industries in which the character of the product depends upon labor combined with process. It is labor applied to fabrication, and the process is almost purely physical rather than chemical. It differs from Group 2 in that the worker dominates equipment instead of equipment dominating the worker. Labor determines both quality and quantity of output in most cases.

All of the industries are synthetical, employing several materials, usually, and producing a variety of products. All of the seven functions of management are fully developed: management or *control* with its general problems; *design*, applied almost entirely to the product; *equipment*, involving mainly the selection and care of standard machinery, problems of transportation of material, and power; *operation* in its highest form as regards the personality, training, coördination, and care of workers; *purchasing*, storage, and distribution of material in most complex form; *accounting* in most elaborate form by reason of the varied product; *sales*, in many industries involving extensive organization in widely scattered territory.

The following may be classed in this group:

Leather goods, belting, and novelties.
Tobacco goods.
Furniture.
Gloves and mittens (leather).
Musical instruments.
Printing and publishing.
Clothing and furnishings for men and women.
Jewelry and precious stones.
Clock and watch making.
Toys, games, dolls, etc.
Brooms and brushes.
Professional instruments.
Firearms and ammunition.
Locomotive and car shops.
Shipbuilding.
General machinery and machine shop products.
Vehicles, including automobiles, bicycles, carriages, etc.

The classification of industries into these four groups is not presumed to be a hard and fast one. The dominant element as to character of product may not always accord, in individual cases, with practices based upon human judgment or upon special peculiarities in material. Progress is taking place in all lines, and in some cases development in process may be faster than that in equipment, and in other cases the reverse is true. Process and the equipment for it are continually superseding labor. The main purpose in such a grouping is to call attention to the fact that promoters, organizers, and managers of enterprises must recognize the differences which exist. Manufacturing is not a haphazard game of chance to be learned after money has been invested and operation, probably at a loss, begun. It is a science with a definite basis in fundamental principles. The science is not mastered when the business man understands investments and currency. It is not mastered when the tech-

nical engineer understands design and equipment, or the chemist the process. It is not mastered when the wandering theorist devises operating instruction cards and cost-accounting forms and imagines himself a scientific managing expert. It is not mastered when markets are found. It is mastered only when *all* of the factors are understood and applied in a manner which is in keeping with the universal laws of economics and humanity; when it is understood that those factors bear in all enterprises but with differing intensity and that the truly important requirement is to understand the relative weights for the enterprise at hand.

CHAPTER II

ANALYSIS OF PRODUCTION FACTORS

In the first chapter seven primary production factors were mentioned. They represent as many influences of the physical sort, which set the conditions for an enterprise. No organized industry exists that does not have something to do with every one of these factors. For every such industry there is a special combination that represents maximum efficiency, wherein each factor is in proper relation to every other. It is the province of industrial plant design to analyze and compare, thus to find the proper relation, and then to create the physical plant that will enable effective management to realize the possibilities in full measure.

Some of these factors are capable of expression in numerical terms, and therefore of direct comparison. The several concerns engaged in the production of any given article may be expected to show similar results in such comparison, barring accidents peculiar to some localities. Thus it is that capital, cost of materials, labor, and power are related quantitatively in any single industry. What this relationship is, is shown in the following pages for fifty typical branches. In any one industry the process is approximately uniform, save as improved production methods may bring about differences. The scale of operations is an index of such improvements, setting possible standards in the way of specialization and mass production. With an available basis of comparison which represents average conditions, the plant designer has a check on his accomplishments in improving operating conditions in his individual plant.

The market and transportation facilities are external factors. The latter have been dealt with already in their general bearing on industrial development and will not be considered further now. It is understood that the means for the movement of material into and through the plant are included in equipment. Switching and yard facilities to connect the plant with railroad lines

are items readily adjusted, although sometimes presenting problems of some magnitude. If it be taken for granted that the designer proceeds wisely in placing his buildings with reference to existing lines, then the arranging of shipping facilities becomes a matter of detail planning.

The market is what makes or breaks many industries. Its importance is such that its study becomes the primary element in plant design, and it is made the principal topic of the next chapter. If market justifies a plant at all, and if we assume the wit and personality to organize and manage, then we may proceed to analyze the problems of capital, material, labor, and power on a money basis, if we know enough about process to enable us to exercise judgment.

Industrial enterprises, in general, are started according to one or the other of two plans. The one is found when the plant is an outgrowth of an older concern, having behind it the accumulated experience of years of operation. The new establishment may be planned to replace the older, or it may be a branch to care for market demands in new territory. For such a case, the relations of capital to the other internal factors are capable of determination at once, with such modifications as the newer design may offer in the ever present attempt to improve upon conditions. Commonly, the new plant will be built complete as to size and capacity, and in it the engineer will have the opportunity to realize at once on his skill as a designer.

The other plan followed is when an entirely new enterprise is to be created. Usually, this means starting on a small scale, with arrangements for future growth to be provided. The problem here is more difficult than in the former case, since the initial construction must be made reasonably effective, while at the same time the completed plan is to be kept in mind. The time has gone by when businesses may be built up by the haphazard methods of simply adding buildings and equipment in kind to small initial plants. The advantages to be gained from quantity production in the full-sized plant of the future must be foreseen. The small buildings of the first plant must be adapted to extensions that are to come, and equipment must be selected and arranged in accordance therewith. It is to the designer entrusted with this task, possibly in a field with which he may be in a measure unacquainted, that the data to be outlined in this chapter may be most valuable.

NUMERICAL ANALYSIS OF THE INTERNAL FACTORS

Capital, cost of materials, number of, and wages paid to, employees, and power demands and cost are the elements to be considered. They are the true factors affecting the internal operations of the producing plant, where process rules. What the designer needs to do is to gain an adequate idea of the cost of production in advance of investment; or, at least, to estimate the operating income and expenditures involved in the operation of the plant. To do this he must draw upon the experiences of many like enterprises, modifying, where desirable, in accordance with judgment based on knowledge of conditions.

For such an analysis the value of product stands as the gross income, the first outlay being for raw materials. Between these two quantities we find at once a great variation in relative magnitude. In certain industries the increase in value of the material is small; in others it is large. In fact, the industries differ so radically in this respect that the value of product turned out by an enterprise cannot be accepted as a measure of the significance of that enterprise as an industrial element in the community. It is increase in value, commonly referred to as "added value," that is the truer measure.

Added value, therefore, calls for careful consideration. By it we mean the value created by the manufacturing process, plus possible increments to value coming from marketing conditions. The latter is an adjunct to the fabrication of the material into the finished article and hence is itself directly traceable to the process. The added value is wealth produced, and hence is the measure of importance of an industry in a town. From this portion of its receipts a company must pay its labor, make returns on capital, pay power costs and sales expenses, and build up its reserves for depreciation and all contingencies of operation—in short, run its business in every line except paying those who have started production by furnishing the raw materials.

It is clear that these materials thus eliminated from operating problems must include those which actually enter into the finished article or are strictly process materials, like certain chemicals, that affect the constituent material as to character and thus produce the qualities which give value to the product. Unfortunately, the U. S. Census Bureau has included with materials all kinds of supplies that are purchased, including fuel for power as well as for direct process. This makes difficult the

use of most valuable as well as the most available statistical data.

In the following analysis of 50 representative industries, figures from the Census of 1910 are used. Of course the absolute values have changed radically in 14 years, but the primary object of this analysis is to show relative values, which have not changed so much, and methods of procedure. It is not probable that the order in which the industries appear in the list has changed very much, unless by reason of temporary violent fluctuations in prices that would be out of adjustment with wage scales. As a matter of fact, it is safer probably to use these quantities for this special purpose than to use the 1920 reports, which are in reality the figures for 1919, and which show industrial conditions at the most abnormal stage in an abnormal period.

In using these Census reports the item "added value" has been corrected for fuel and supplies incident to power. That is, there has been deducted from cost of materials a certain amount representing power fuel and supplies, which means adding the same to the added value. The correction is determined as follows:

The Census shows power produced by heat engines and total fuel purchased for power and process combined. A list of 26 industries was selected in which no process fuel is employed except in a nominal way for forging and foundry purposes, where those processes are incidental. From this, two average figures were calculated for fuel per horsepower per year, one for industries where large establishments are the rule, and one for those wherein small establishments prevail. At a uniform price of $2.50 per ton these two figures are $16.20 and $19.70 respectively. The amounts of coal correspond to 4.4 and 5.28 lb. per horsepower hour. To each figure for coal, $6 is added to cover cost of water, lubricants, packing and miscellaneous supplies, and repair parts and materials, giving $22.60 and $25.70 per year as the cost per horsepower of commodities that are included with materials in the Census. These average figures are then multiplied back into horsepower for all of the industries, in each case according as large or small establishments prevail, and the correction applied to the added value. For industries like wood pulp and paper, and cotton milling, which use large amounts of water power, a further correction might be made to cover the repair materials used on the water equipment, but it is a refinement that is hardly necessary.

The accompanying table shows many significant facts which should be given careful attention. The industries are listed in the order of their added values per thousand of actual value of products. The range is surprising. For the same value of finished goods, the last industry on the list creates more than nine times as much wealth as does the first one. It employs nine times as many people, uses twice as much capital, twice as much power, and puts ten times as much wage money into circulation in the town. Or take the two largest industries, meat packing and general metal manufactures. For the same value of output, the latter creates four and a half times as much wealth, employs five and a third times as many people, and puts six and a third times as much wage money into circulation as does the former. When capitalistic owners make the statement, as they sometimes do, that their profits amount to only, say, 3% on their total sales, that means a profit of 10.7% on capital invested for the meat packer and only 2.44% for the metal goods manufacturer.

The third column figures indicate, therefore, the relative desirability of industries as community assets, modified by the figures in the labor and wage columns, so long as people continue to measure operations by the extent of gross sales. Naturally the ceramic industries, brick, tile, pottery, and cement, stand high in the list, since their materials have little value until used in the process. Cane sugar refining, on the other hand, uses as raw material the finished product of another complete industry. Many such instances may be observed in the list, but there is no purpose in stressing the point. The striking differences that exist are to be noted for what they signify, and that is that the production manager must understand and deal with the relative values for his business.

In order that we may really compare the dominating factors, capital, labor, power—all within the control of the manager—it is clear from the preceding discussion that the widely varying element of raw materials must be eliminated. This is done by using added value as a basis, instead of value of product. Beyond the third column of the table, therefore, quantities are based on the unit of $1,000 added value. With that as a basis, every industry stands on its own feet. Value is created—one thousand dollars' worth. How much capital is required? How much power? How many employees? The thousand dollars must cover returns for these three, and also provide for

contingent and depreciation reserves, meet all sales expenses other than personal service, as well as all miscellaneous expenses, such as insurance, taxes, and rent, and supply any profit over the basic return of 6%. It should be noted in passing that 6% return on the figure carried as capital is actually equivalent to 8% or more on net stock investments. As here used, capital is the total of full values of property, including stocks on hand, current cash, etc. Many of the larger concerns have much of this in the form of bonds at favorable interest rates, and all carry an appreciable amount as accounts payable but drawing no interest at all.

Based on added value, these three sets of figures on power, labor, and capital represent, for the several industries, true variations incident to the processes. No general trend of difference is perceptible, as was the case with materials, but marked differences appear. There are a few distinctively high-power industries, notably blast furnaces, paper, and cement. The figures, $22.60 and $25.70, for power cost for large- and small-establishment industries are used here to convert horsepower to cost. These are excessive for blast furnace work and wood pulp paper plants, where the former uses waste gases for fuel and the latter uses water power, and this fact explains the low margin indicated in the last column.

For labor, highly developed machine and chemical process industries show small charges. The smallest one is beet sugar, cane sugar being close behind. Here the process equipment is elaborate, with material handling devices well developed, as is true also of blast furnaces. Hosiery and knit goods carry the largest number of employees, but with a very low per employee wage—$384 per year. Other industries employing women and children show up here with a low wage, such as cotton goods with $380, canning and preserving (seasonal industry) $384, tobacco goods $438, buttons $448. Industries employing skilled workers on specialized articles, like cash registers, typewriters, and emery wheels, have a moderate total wage but a high wage per employee.

For capital, the highly developed processes, such as for blast furnaces, cement, and sugar, call for high investments. Leather tanning is an example of the way in which the process serves to run up investments through the keeping of large quantities of stock under treatment, the investment being in material rather

Industry	Value of products, thousands	Added value (corrected), thousands	Added value per $1,000 of value	Per $1,000 added value: Power		Labor		Capital		Manufacturing margin
				Hp	Cost	No employed	Wages	Amount invested	Return at 6%	
Sugar refining, cane	$ 248,628	$ 23,190	$ 93	$1.66	$37.5	0.45	$314	$4,970	$298	$350.5
Slaughtering and meat packing	1,370,568	172,110	126	1.21	27.3	0.63	417	2,230	134	421.7
Flour milling	883,584	128,128	145	6.56	148.4	0.53	265	2,725	183	403.6
Dairy products	274,558	41,430	151	2.45	63.0	0.76	354	1,720	103	480.0
Cottonseed oil and cake	147,868	32,795	222	0.59	15.1	0.65	309	2,780	166	509.9
Blast furnace	391,429	97,041	248	12.10	273.0	0.44	321	5,020	301	105.0
Leather, tanned	327,874	83,155	254	1.78	40.5	0.81	467	4,000	240	252.5
Glucose and starch	48,799	12,532	257	2.25	50.9	0.47	325	3,100	186	438.1
Zinc smelting	34,206	9,453	277	2.27	51.3	0.76	551	2,940	176	221.7
Boots and shoes	512,798	181,512	354	0.53	12.0	1.19	645	1,225	74	269.0
Steel works and rolling mills	985,723	353,722	354	5.95	134.5	0.74	536	2,840	170	159.5
Cordage and twine	61,020	21,650	355	3.63	82.1	1.26	508	3,510	211	198.9
Canning and preserving	157,101	57,202	364	1.42	32.1	1.26	471	2,080	125	371.9
Woolen goods	435,979	159,071	365	2.28	51.5	1.10	518	2,550	153	277.5
Paper bags	15,698	5,796	369	0.67	15.2	0.64	349	1,860	112	523.8
Paint and varnish	124,889	46,901	375	1.15	26.0	0.47	398	2,220	133	443.0
Confectionery	134,796	54,326	403	0.66	15.0	1.01	456	1,260	76	453.0
Paper and wood pulp	267,657	112,965	422	11.54	260.8	0.72	445	3,790	227	67.2
Awnings, tents, etc	14,499	6,132	423	0.33	8.5	0.94	489	1,280	77	425.5
Dyestuffs and extracts	15,955	6,829	428	3.25	73.4	0.44	327	2,630	158	441.6
Leather goods	104,719	44,985	430	0.63	16.2	0.97	548	1,550	93	342.8
Cotton goods	628,392	277,102	441	4.68	105.5	1.40	532	2,970	178	184.5
Copper, tin, and sheet metal products	199,824	88,222	442	0.71	16.0	0.98	564	2,470	148	272.0
Leather gloves	23,631	10,468	443	0.28	7.2	1.24	575	1,615	97	320.8

Beet sugar	48,122	22,098	459	2.59	58.6	0.38	296	5,870	352	293.4
Hosiery and knit goods	200,144	91,849	459	1.13	25.5	1.48	571	1,780	107	296.5
Chemicals	117,689	55,924	475	3.73	84.3	0.50	362	2,775	167	386.7
Men's clothing	568,077	271,107	477	0.16	4.1	1.00	491	1,015	61	443.9
Automobiles	249,202	119,026	478	0.63	14.2	0.72	489	1,460	88	408.0
Steel springs, car, etc	9,005	4,412	490	1.67	37.8	0.81	554	1,990	119	289.2
Iron and steel forging	20,293	10,505	518	2.65	59.9	0.87	600	2,640	158	182.1
Electrical machinery	231,308	115,158	520	1.38	31.2	0.92	604	2,325	140	224.8
Boxes, fancy, and paper	54,450	29,013	533	0.80	18.1	1.50	610	1,220	73	298.9
Hats, fur felt	74,865	26,136	546	0.74	16.7	1.04	625	1,415	85	278.3
Locomotives, non-railway	31,582	17,278	548	2.06	46.6	0.98	650	3,015	181	122.4
Furniture and refrigerators	239,887	135,422	565	1.64	37.1	1.07	600	1,680	101	261.9
Foundry and machine shop products	1,228,475	703,004	573	1.24	28.0	0.75	591	2,150	129	252.0
Tobacco manufactures	416,695	240,093	577	0.12	3.1	0.82	359	1,020	61	576.9
Buttons	22,708	13,356	588	0.96	21.7	1.35	605	1,170	70	303.3
Agricultural implements	146,329	87,738	600	1.15	26.0	0.68	443	2,920	175	356.0
Sewing machines	28,262	17,220	610	1.13	25.5	1.20	728	1,340	80	166.5
Emery and abrasive wheels	6,711	4,118	614	0.97	22.0	0.59	441	1,510	91	446.0
Stoves and furnaces	78,853	50,332	638	0.90	20.7	0.85	595	1,330	79	305.3
Cement	63,205	40,982	648	9.07	205.0	0.72	463	4,580	275	57.0
Cutlery and tools	53,266	36,016	676	1.90	43.0	1.03	604	1,870	112	241.0
Pottery and fireclay products	76,119	56,617	745	1.94	43.8	1.08	628	2,500	150	178.2
Typewriters and supplies	19,719	15,770	800	0.43	9.7	0.77	566	1,680	101	323.7
Brick and tile	92,777	76,376	832	4.47	101.9	1.12	558	2,290	137	204.0
Cash registers and calculating machines	23,708	20,281	855	0.34	7.7	0.46	397	1,340	80	515.3

than equipment. Men's clothing and tobacco goods stand at the bottom of the list, and likewise enjoy a generous margin.

The manufacturing margin is the sum remaining from the $1,000 after paying for power, labor, and the 6% return on capital. Special comment is unnecessary. It is not to be interpreted too literally as an indication of a profitable or unprofitable business, since there are many qualifying conditions to be considered, as noted in a preceding paragraph. Detailed studies of operating expenses are necessary, illustrations of which are given in Chapter IV, before drawing conclusions as to the financial situation. What this analysis does show are the relative influences of power, labor, and capital in the selected industries, and, in the first part, the influence of raw and process materials on the relative magnitudes of created value and total value of the product of an industrial enterprise.

HOW TO USE THE TABLE VALUES

Any one concerned with the organization of a new enterprise will find it profitable to check his estimates by these relative figures; but this must be done with a full recognition of their character and origin. They are averages of a large number of established plants. In several cases, such as for foundry and machine shop products, the entry in the table is an average for many different varieties of products. Each individual plant has its own peculiarities, and the one that is being planned new must be expected to vary from the average. Land values, building costs, and other local factors will enter into the estimates and make investments larger or smaller. No set rule can be applied without an ample application of good sense and adequate knowledge of the special conditions.

Preliminary work on an enterprise is carried on with regard to the extent of the expected business. One must have a definite idea of how large a scale he will operate on. This will be expressed in terms of the output in quantity and value if the market has been studied, provided the article has limited sale possibilities. This phase of the question is the leading topic of the next chapter. With value of goods produced fixed upon as the leading item, simple percentage calculations will give the added value, number of employees, power requirements, and the approximate capital. In this it will be kept in mind that this

figure for capital is taken as defined by the U. S. Census Bureau, including all visible property, such as stocks on hand and in process. That is, it includes operating capital as well as initial investments, part of which may be expected to be accumulated gradually through the application of earnings to the building up of the plant. Allowances for this will be made according to judgment.

If the goods to be manufactured have sale possibilities that are beyond expected producing capacity, then the size of the plant may be determined by the amount of available capital. After adding to the sum available a safe allowance for the additions to plant that may be expected to accrue as operation proceeds for a few years, on the basis suggested in the last paragraph, the sum corresponding to capital as used in the table is secured. This is then divided by the capital reference figure to convert to added value, and the other factors calculated as before.

A similar calculation is made should the projected plant be based on the number of employees. While this is more unlikely to be the basis for estimating plant capacity, still it is a possible method of arriving at an estimate, and under some circumstances might be used.

Exercises for Class Use

1. A concern manufacturing trunks, suitcases, bags, and a line of miscellaneous leather goods does an average annual business of $200,000 in gross value of product. Assuming present prices to be 30% higher than in 1910, reduce to the corresponding value, and find each of the other quantities included in the table.

2. A wholesale dry goods firm decides to start making men's overalls. An estimate shows that about 80 women workers would be available in the town. Five men would also be employed. Find from the table the capital, power, and value of goods produced. Convert value of product and wages to present standards on assumption that finished goods are 30% and wages 40% higher than in 1910.

3. An agricultural implement firm decides to establish a branch plant in a western town, investing therein $300,000. The company is able to provide working material on terms such that capital, as used in the table, may be taken at the full amount. That is, by reason of its standing and prestige this company can do as much with $300,000 as an independent concern could have done in 1910. Solve for number of employees, power demand, and value of product, converting the last item to present value on the basis of an advance of 45% in prices.

4. Refer again to the data in Exercise 1. Use the values there found for capital, number of employees, and horsepower, but add 20% to capital to allow for difference in cost of plant, in excess of costs in 1910.

Assume the following list of capital items:

Land and buildings	$30,000
Equipment	45,000
Material in stock and process	20,000
Finished goods on hand	20,000
Balance in cash and miscellaneous property.	

Work out a statement of operating costs on the following plan:

Annual gross income from sales, $200,000.

Materials, 40% above amount from table. (This covers supplies, replacements of small tools, and miscellaneous.)

Labor—wages on basis of 2 men at $175 per month; 6 at 60 cts. per hr.; 16 at 30 cts.; 8 at 25 cts.; balance at 40 cts.; for average of 2,400 hr. per yr.

Power at $35 per horsepower per year.

Repairs and maintenance, 2% of value of equipment.

Insurance, 1% on property items above.

Taxes, 2% on two-thirds of same property items.

Depreciation, 2% on buildings; 5% on equipment.

Find the balance available for return on investment, and work out a new set of table values representing present conditions.

CHAPTER III

PRELIMINARY DESIGN

The successful enterprise, as it is planned and established under present-day conditions, does not become so by accident. Every step in the process of design must be taken with care and with consideration of the relative importance of the several conditions which will bear upon it. Design must be interpreted always as being the process of determining the character of the product. Designing a plant includes, therefore, all of the decisions that are made respecting class and type of article to be manufactured; the marketing territory with its needs, purchasing power, buying habits, and avenues for distribution; the type of sales system to be employed; the location of the producing plant; meeting of competitors; adjustment of transportation questions with the carriers; purchasing or development of materials; general power system to be employed; types and abilities of available labor; and all other matters which may influence the character of the plant that is to be built. The later design of the physical plant consists in the fixing of the means for carrying out the major plan that is evolved by the preliminary studies.

The market is the first consideration, now being considered in its general aspects without special thought as to location of the plant. The motive prompting the determination to engage in the business may be any one of a score of influences, but if a man has decided to enter upon the manufacture of a commodity, he must be sure of disposing of his product. The first thing to do is to decide what market he will cater to. The second is how to develop it. The third is to study the reflex effect which the market will have upon the character of the commodity itself, upon the size and location of his plant, and the form of his organization.

SELECTION OF A MARKET

For some kinds of product, the kind of market is perfectly obvious. One produces locomotives for railroads; automobiles for highway traffic; dyes for the textile industries; beet

sugar for domestic consumption. Wherever there are people and traffic needs, and demands for clothing and food, there is bound to be a market. Articles that are standardized, such as portland cement, refined sugar, paving brick, and news paper, are determined in advance as to character and will suit any market that observes the standard. Other products are in a continual stage of development and perfection, but under the control of the manufacturer. Locomotives, automobiles, cash registers, and shoes—for all of these the market looks to the producer to set the standards and bring out the new models, after which it will buy according to its judgment of quality and fairness in price. The plant designer looks to the inside for the distinguishing traits that will fix the model and so settle questions as to kind. Wherever the goods are to be sold, the type is fixed.

For other commodities this is not so. Agricultural implements destined for New England differ from those going to Dakota; those destined for Mexico, from those going to Australia. Cotton cloth for the China trade differs from that to be sold among the southern negroes. Mining machinery going into the mountain regions of South America must be built for primitive means of transportation. Derby hats could not be expected to capture the trade of Panama or India, nor silk hosiery that of Labrador. These are examples of extremes. In a finer sense the same principle applies in a multitude of ways. Custom, habits, styles distinguish and define the prime characteristics of many commodities. Advances in the arts, such as the use of aluminum alloys in automobile construction, give rise to extensive enterprises turning out new products. For this general group of industries, the market question must be settled definitely before the plant designer can even start on his task. He must know *what* to manufacture before proceeding to determine *how*.

Still another group calls for a different analysis of the possibilities of any given region. A new article has been devised. Where will it find its best demand? A new brand of steel for cutting tools would look to machining centers. A new tractor, like the Fordson, may take well in certain agricultural regions where the farmers are prosperous and progressive. Steel office furniture sells well in rapidly growing cities where insurance regulations and building ordinances are becoming stricter. The same is true of the zinc and asbestos roofing materials. A new

fertilizer will find its market where soil conditions are such as to respond to its use. For all such, it is a matter of deciding where the article is adapted to the needs of the people or where the people have the characteristics and means which make possible a campaign for popularizing a thing of convenience, beauty, or economic usefulness.

Decisions in this line are made naturally at the original inception of the enterprise, by those who are projecting the idea. The initial plan is subject to revision and variation as work proceeds, under the impress of accumulating data and experience. Too great emphasis cannot be given to the importance of the studies made before the plant assumes form. A correct relation to market is necessary to success. Concerns without number have failed because of inadequate marketing plans and facilities. This relation is not an engineering function in itself, and, like many of the elements of business, was very often given only a superficial consideration in past years, on the supposition that the commercial insight of someone high up in the councils of the company was sufficient. Many a business has been started with no better basis for a marketing plan than somebody's assumption, or guess. There is no reason why estimates may not be made, based on population studies and records of consumption of the article in question over a series of years. If the article is new, then some estimate of possible sales in a typical community can be used. Systematically arranged data are always of assistance, even if only as a guide to a guess at the end.

Reports of the U. S. Department of Commerce are now giving valuable information respecting the foreign demand for goods. More and more this country will turn to the export trade. The saturation point in domestic consumption is being reached in many industries. As attention veers to the foreign market, many phases of managerial control will be subject to change, and the careful analysis of market needs and consuming power, as well as policies in credits and banking practices, will become increasingly important. These matters are merely alluded to as bearing a definite relationship to the work of the engineer, with no effort to amplify as to methods of procedure.

DEVELOPMENT OF THE MARKET

In increasing measure, engineers are taking on the sales function in enterprises handling various kinds of commodities. This

is true especially when the articles to be sold are designed for application to structures or to technical enterprises, and so have a direct bearing on operation. The correct use of an article may be the means for building up confidence and future trade. The result is that the selling force acts often in an advisory capacity to the purchaser. A little thought makes it clear that the manufactured products coming within this category make up a long list. It is necessary to have an adequate understanding of marketing methods as a basis for the planning of any selling campaign.

The Wellington doctrine as to the minimum combined cost of production and transportation should be extended to include cost of selling. In many lines selling cost today is a heavy tax on the consumer. In placing the product of a factory on the market, this fact should be given attention. Only by full study can the best program be determined upon.

Trade in its earliest form, barter, involved direct contact of producer and consumer. The next step was the advent of the retailer, who took the produce from one group and sold to the other. The reader may amplify at will the forms which retailing developed while it still existed as the one intermediary between producer and consumer. As producers developed their activities and turned out goods in large quantities, no single retailer could take the entire output of a factory. Hence the producer was confronted with the burden of selling to many retailers as his small-scale predecessor sold to consumers, and in various lines it was found economical for him to reduce the number of his trade connections in similar manner. This was done through the medium of the wholesale merchant, who bought in larger quantity and resold to retailers, combining a large range of commodities by buying from several producers, so that he could more nearly meet the needs of his customers, the retailers. Sometimes the wholesaler could take the entire product of the manufacturer. Today we see many overall factories, canning and preserving plants, and various other enterprises turning their whole product through one wholesale house, the latter sometimes owning the manufacturing business. Sometimes this has not been practicable, however, and so we have seen a third intermediary, the jobber, develop in business circles, his function being to handle the entire factory output more directly, selling to wholesale firms. When thus serving the manufacturer, the

jobber takes the selling function from the former's shoulders, substituting his own selling organization for the one which the manufacturer would otherwise be compelled to maintain. The justification for this procedure lies in the fact that the jobber serves several manufacturers at the same time, and so can cover the ground with a single force selling a large variety of articles, whereas, in his absence, each manufacturer would be covering the same ground, selling his own smaller variety.

Still another functionary has appeared at times, styled the "commission merchant," but the distinction between him and the jobber is somewhat indistinct, and it is not necessary at this juncture to follow out the matter in detail. In the handling of manufactured articles especially, the selling chain of manufacturer-to-jobber-to-wholesaler-to-retailer-to-consumer is adequate to represent the process in its most involved form.

There is much loose talk about the wastefulness of middlemen. To be sure, all of these steps in the marketing process are not necessary for all kinds of products, and so is it true, likewise, that for many lines of goods some are omitted. But they perform a real function. Someone must sell, and it is simply a question as to who can do it most economically. The margin on which the jobber and wholesaler operate stands in the place of sales expense on the manufacturer's account. As said before, by handling large stocks coming from several producers, one selling organization can replace the several organizations that would otherwise be necessary, and therein lies economy. It is more satisfactory for the retailer, also, to be able to order many different portions of his stock from a single wholesale house. Hence wholesale condemnation of middlemen is out of place. The conclusion of the whole matter, when taken from the present viewpoint of the manufacturer deciding upon a selling plan, is that he must study the situation as it exists with the same scientific care and accuracy that he would exercise when dealing with production problems, discarding set rules when they are proved unsuited to his needs, not fearing to take steps dictated by economy.

But there is much cutting across the old selling chain today, even in many stock commodities, and especially in manufactured goods that are of specialized character. The chain store is one of the most notable factors wherein a retailing organization is enabled to buy heavily, sometimes taking entire factory output,

and distributing to its many branches. Large shoe manufacturers with many branch factories are able to multiply styles while keeping each branch on a mass production basis, each turning out a limited number of types, so that the central selling organization of a single company can fill orders including many styles and grades and so perform the typical function of a wholesaler. Leather tanning is passing largely into the stage where producing and selling are merged into the one organization, although for some varieties of leather the jobbing interests are still active. Paper mills sell direct to many large publishing houses. Producers of such commodities as cement, paper boxes, dairy products, starch, electrical supplies, brick and tile sell direct to large customers, to retailers, and sometimes also to wholesale firms or jobbers.

In marketing the more specialized products a still more varied practice prevails. Many pass direct from manufacturer to consumer, sold either from a maintained stock of standard design or on special order. If the former, the selling may be done by (1) a traveling representative; (2) through the mails; (3) through selling agents operating from marketing centers where stocks may be kept, or not, according to character of the articles, the agents being employees of the producer; (4) through independent agents who acquire the right to handle the articles in a given territory and in whose name sales contracts may be written, and who may have similar agencies with other producers of related goods, thus giving them a line of articles to meet the needs of the trade. Various combinations of these methods are employed, whereby portions of the plant output may be disposed of in one way and other portions in another. When the article is one that has especial fitness for certain kinds of service, as is the case with electrical power equipment, there is occasion for trained representatives of the manufacturer to take part in negotiations, even if independent agents have to do with the making of the contract. In starting the production of new machinery lines it is often of advantage to arrange in advance with well-established sales firms for the handling of the output, as a means for introducing them on the market in several sections simultaneously.

Keeping in mind the selling methods thus hastily sketched, the prospective manufacturer must go over the situation with the purpose of deciding upon a plan adapted to his enterprise. If the home market alone is in view, he will select the territory

seemingly most favorable and proceed to the forming of the trade connections that will serve his purpose. This means choosing centers from which to work the territory, arranging with agents, laying out his own organization for handling the sales work, and studying any and all phases of the trade demands. He must know the goods of competing concerns already in the field and study the methods in their handling. He and his agents must go carefully through the territory to make detailed estimates of the purchasing power of prospective customers, and of the portion of the trade which he may expect to control. If his article is an entirely new one, so that he will have no competitors, then the problem is the extent to which he may hope to induce purchases by those for whose needs his goods are adapted. The extent of first-season sales must be estimated, on the supposition that the regions will have to be worked over several times before they are really developed and the business placed on a normal basis. The magnitude of the task is in inverse proportion to the experience of the man who is doing the estimating. Optimism in a sane degree is necessary, along with confidence in one's ability to carry through what is usually a difficult undertaking requiring patience and a good supply of capital; but an unjustifiable optimism must be guarded against.

The object of all this is to fix upon a reasonable producing capacity for the proposed plant. The market analysis should furnish a basis for deciding how much to plan for, and whether the initial capacity should be made small—with plans for enlarging as the business develops, or whether full capacity should be provided at the start. The amount of available capital will influence the decisions at this point. The basis on which density of trade may be estimated will vary with different enterprises, as the following illustrations serve to indicate.

Assume an enterprise in process of planning for the manufacture of a line of tools used in garages—not the finer grades of lathes or other machine tools, but rather the less finished forms, including jacks and miscellaneous small tools of the rougher sort. The customers will be the garages and certain individual car owners who are mechanically inclined and desirous of maintaining their own machines. The extent of the prospective market will have a relationship to the number of auto vehicles in the territory under consideration. Data as to the rate of increase in number of cars and, specifically, as to the number of

existing garages and the ratio of that number to the cars owned in the territory, will be required in order to estimate future demand for equipment. The extent of automobile tourist travel through the region will also be a factor, together with a study of tendencies in the direction of highway improvement, opening up of new pleasure resorts, and shifting of routes of travel. In this line of products it is necessary to consider carefully the strength of competitors in the field. Conservatism in estimating the extent of sales should be exercised.

Representing a very different product, take the cement business as an example. The figures for 1914 are used. In that year the average per capita consumption in the continental United States was 0.84 bbl. Among the states, however, the amount used varied from 1.70 bbl. in California to 0.11 bbl. in Mississippi and South Carolina. Montana and Iowa follow closely on California with 1.68 and 1.61 bbl. respectively. Such figures present two interesting facts for the man considering a market for cement. Without question, the more active states present the better field for sales. Construction work has gotten well under way and the people are getting acquainted with concrete structures. Such districts will go forward rapidly. On the other hand, the backward states constitute a rich field for the more distant future, when activities calling for cement shall have gotten under way. The first significant point to register is, therefore, to look out for shipping facilities in two directions—one toward active regions, where the better immediate market will be found, and the other toward regions that may ultimately be depended upon when competition in the first territory becomes keener.

More specifically, a manufacturer shipping out of the Kansas City district would have immediate access to the states of Missouri, Kansas, and portions of Iowa and Nebraska, in all of which the 1914 rate was 0.81 or over, and also to Oklahoma, Texas, New Mexico, and Arkansas as reserve markets, where the rates were 0.25, 0.43, 0.68, and 0.24 respectively. A plant in the St. Louis district could sell in the rich markets of Illinois, Iowa, and Missouri, and also enjoy especially good shipping facilities to Kentucky, Tennessee, and Mississippi, where the consumption rates were 0.37, 0.36, and 0.11.

For materials like cement, structural steel, and many others, the probable future demand may be estimated in accordance with

public works programs. The author has made a rough approximation of the cement that will be used in Kansas during the 10 years beginning with 1921, for the roads, bridges, and public buildings alone, in which the state will have a direct interest. It amounts to nearly 0.9 bbl. per capita per year. That used in municipal structures and by individuals will swell the amount, probably to 1.25 bbl.—a substantial increase over 0.81, the figure for 1914. From such estimates, and with knowledge of the producing capacities of plants already serving any district, one may draw conclusions as to the wisdom of establishing a new plant as respects marketing possibilities.

Other commodities vary in some direct relation to the population, in which group come the principal food products, boots and shoes, ordinary textiles, paper and paper goods, and many lines of clothing. The per capita consumption for all these articles is likely to vary, so that data showing the rate of change must be available to make it possible to estimate with accuracy the consuming power of any community for the future. Such information is given in the accompanying chart for certain representative commodities. The figures there used are production rather than consumption values, the amount of the goods exported not being allowed for. When used on a scale for purposes of estimating the added producing capacity that the country may support, it is not out of place to use these production figures, since it may be assumed that sales in foreign territories will advance in approximately the same ratio as in domestic. In matters like this, however, there is occasion for exercising good judgment in making estimates.

Let it be said, however, that right here is the point where promoters and organizers must stop and study with care if they are to be safe leaders in industry. On the thoroughness of the investigation of these conditions rests the chance for success, or at least the chance to avoid costly experiments in production.

FINAL STEPS: LOCATION PROBLEMS

If the matters of market and character of product are satisfactorily adjusted, there remain various physical factors to be investigated before the characteristic design can be completed and the general location decided upon. The important ones are materials, as to quality and supply, process materials, such as

PRODUCTION OF CERTAIN COMMODITIES IN THE UNITED STATES

Product	1919		1914		1909		Remarks
	Amount produced	Per capita	Amount produced	Per capita	Amount produced	Per capita	
Wheat flour, barrel	132,465,604	1.250	116,403,770	1.150	105,756,645	1.1800	
Starch, pound	677,535,647	6.400	620,764,347	6.110	783,513,087	8.7400	Glucose branch of industry increased since 1909.
Sugar, refined, tons	4,243,362	0.041	4,076,607	0.040			
Canned vegetables, cases	57,471,295	0.544	50,258,674	0.495	34,656,179	0.3870	
Canned fruit, cases	21,432,393	0.207	9,449,182	0 093	5,528,878	0.0620	
Pig iron, tons	30,543,167	0.289	23,269,731	0.229	25,651,798	0.2830	
Steel, rolled, forged, etc., tons	36,211,947	0.342	25,522,784	0.251	26,723,274	0.2980	Lower since 1919.
Cement, barrel	81,306,524	0.770	89,049,766	0 876	......	....	Approx. 0.92 in 1922.
Boots and shoes, pairs	286,592,960	2.710	252,516,603	2.480			
Paper, tons	3,286,140	0.031	2,600,400	0.025	2,160,830	0.0241	

fuel and water, and transportation facilities. They must be considered together, always with the problem of location in mind. Certain general principles have already been mentioned, in the opening chapter.

Distinctions must be clearly drawn as to the relative importance of constituent and process materials. To do this a knowledge of the manufacturing process is necessary, or at least an intimate understanding of the characteristics developed in Chapter II.

In general, industries with a low ratio of added value to value of product are conditioned by the sources of the constituent materials, although there are exceptions. Materials of low value per unit of weight cannot be transported long distances. The railroad rate fixing boards recognize this when setting low commodity rates, but even with this help there is a limit beyond which certain low-value commodities cannot be moved. At the other end of the scale the high added value minimizes the significance of transporting materials. With the latter, however, fuel demands where heat treatment is involved in the process, unusual power demands, or quality of water used in process may be controlling factors, singly or in combination.

It has been stated that some industries follow the market. This is because their raw materials may be shipped on low commodity rates, whereas the product is bulky or perishable and takes a high rate. In general, these are cases where added value is large. Material here is moving toward the ultimate consumer at all times, which is a natural condition. More industries would come in this class were it not for certain artificial or personality conditions which make it impossible to realize a truly scientific industrial system. These influences are mainly the characteristic tendency of labor to segregate where accident or habit has placed it in the past, and the artificially adjusted freight rates, which prevent cost of service from entering more logically into the charge. This explains why wool is shipped from the Rocky Mountain states to Philadelphia and New England and woolen goods shipped back. Australian wool coming into Atlantic ports is on its way to market, however, and so follows the natural law.

The principle of fabrication in transit is an important one in the location of industries. The plant must be so located that finished goods may reach consumers at the lowest average cost, in which these items appear, namely,—

1. Cost of fabrication, including materials but not freight on same.
2. Freight on materials to the plant.
3. Freight on finished goods to consumer, average.

In many cases the cost of fabrication will be the same in each of several tentative locations, but there may be circumstances which will cause differentials. Costs of real estate and of labor are the items most likely to bring this about. In some high-power industries the rates on electric power may be a third influence. Whatever the situation, the facts must be determined by accurate estimates.

The second and third items may be lumped into a single calculation. Suppose that for every 100 lb. of finished product, boxed or crated for shipment, there are required 85 lb. of raw material that will be brought to the plant on a low classification commodity rate, other materials being procured locally on approximately equal terms for all locations. For tentative locations, *A*, *B*, and *C*, let the freight charge on this material be represented by *X*, *Y*, and *Z*, respectively. If the product be of a type such that the market demand will have relation to population, the analysis may be completed by taking a considerable section of the country with, say 30 millions of people, blocking it into relatively small sections with representative cities as centers, and listing the freight charge from each of the tentative plant sites to each of these centers. For location *A*, add *X* to each of these freight rates, for location *B*, add *Y*, and for location *C*, add *Z*. This will give the transportation cost on each 100 lb. of goods shipped to each marketing center.

Suppose, now, that 100 lb. of goods are shipped to each center. If we multiply the population at each center by the transportation cost determined as above, sum up all the products for location *A*, and then divide by the total population, we get a transportation reference factor. The same process repeated for locations *B* and *C* will give reference factors pertaining to them. The one having the lowest reference factor will be the one most favorably situated from the standpoint of transportation. In making this calculation it is necessary to make the population divisions small in the region close to the tentative plant location, since freight rate differences are larger for short hauls; but for more distant regions large units may be used, even to the extent of taking

entire states with their dominating cities as the points for rate determinations.

Similar analyses may be made for types of industries in which the market is not proportional to population, by taking quantity estimates of sales in prospect at various points, as indicated in previous sections of this chapter, and using direct quantities with freight rates in the multiplication, dividing the total by the amount of goods shipped to secure the reference factor. In such work, whether using population or quantity of shipments, calculations are simplified by dropping several digits, either to hundreds or thousands, and so obtaining smaller numbers, which are more readily handled and sufficiently accurate for estimating purposes. The results are purely relative in every case.

The following illustrations serve to make clear the methods outlined above.

1. A concern formed to manufacture plain furniture for the market west of the Mississippi River, except the extreme northern and Pacific Coast states, is considering locations in Omaha, Kansas City, and Oklahoma City. Fabrication costs are equal for the first two, but are 5% greater in Oklahoma City, due to the labor situation. Lumber supply—oak from the North and Kentucky-Tennessee region; pine from the South. All freight rates are assumed, for illustrative purposes only. (Table next page.)

The comparison is favorable to Kansas City by a considerable margin, as could have been foretold from general considerations. It is situated midway as regards shipments of lumber for raw material, where pine is assumed to be used in large proportion, and it is the natural center of distribution for the southwestern region. Had the Gulf states been omitted and the northern tier of states included, Omaha would have shown to better advantage. In an exact analysis the relative accessibility of Omaha to lumber from the Northwest would be considered.

2. Through the courtesy of the St. Louis Chamber of Commerce, the analysis on page 55 is made available as an illustration. It is based on actual freight rates for distribution from the cities indicated, assuming that the raw materials are obtainable on equal terms at each manufacturing point. It is applied to a region with a total population of about forty millions. It represents the drug manufacturing business, the product being one whose market demand runs in proportion to the white population, but not to the colored. Accordingly, the figures

FREIGHT ON MATERIAL, MOSTLY LUMBER, ON A UNIT OF PRODUCT

To Omaha	25 cts.
To Kansas City	20 cts.
To Oklahoma City	25 cts.

ANALYSIS FOR REFERENCE FACTORS, TOTAL TRANSPORTATION

Basis of a Unit Shipment to Point Indicated. Population Figure Used for Each Center Represents a Trade District

Section center	Population 10,000's	Omaha		Kansas City		Oklahoma City	
		Rate	Product	Rate	Product	Rate	Product
St. Louis	90	70	6,300	50	4,500	100	9,000
Davenport, Iowa	30	60	1,800	60	1,800	110	3,300
Des Moines, Iowa	60	35	2,100	40	2,400	100	6,000
Sioux City, Iowa	30	35	1,050	70	2,100	100	3,000
Kansas City	60	45	2,700	0	0	60	3,600
Chillicothe, Mo	20	70	1,400	30	600	95	1,900
Springfield, Mo	20	70	1,100	30	600	60	1,200
Little Rock, Ark	40	135	5,400	95	3,800	40	1,600
Fort Smith, Ark	25	130	3,250	90	2,250	35	875
Shreveport, La	15	140	2,100	90	1,350	40	600
Baton Rouge, La	40	150	6,000	100	4,000	60	2,400
Houston, Tex	50	140	7,000	100	5,000	45	2,250
Dallas, Tex	50	130	6,500	90	4,500	35	1,750
El Paso, Tex	20	140	2,800	125	2,500	75	1,500
Oklahoma City	30	80	2,400	55	1,650	0	0
Tulsa, Okla	20	75	1,500	50	1,000	35	700
McAlester, Okla	15	80	1,200	55	825	40	600
Wichita, Kan	30	70	2,100	50	1,500	35	1,050
Salina, Kan	30	60	1,800	50	1,500	65	1,950
Leavenworth, Kan	20	45	900	30	600	70	1,400
Garden City, Kan	20	95	1,900	65	1,300	75	1,500
Omaha	60	0	0	40	2,400	80	4,800
Lincoln, Neb	20	35	700	45	900	80	1,600
North Platte, Neb	20	65	1,300	95	1,900	130	2,600
Pierre, S. D.	50	40	2,000	75	3,750	115	5,750
Casper, Wyo	50	105	5,250	110	5,500	120	6,000
Salt Lake City, Utah	50	125	6,250	125	6,250	140	7,000
Denver, Colo.	60	100	6,000	100	6,000	125	7,500
Albuquerque, New Mex	30	130	3,900	120	3,600	140	4,200
Phoenix, Ariz	20	150	3,000	140	2,800	150	3,000
Totals	1,075 = 10,750,000		90,000		76,875		88,625
Reference factors			83.7		71.5		82.5

for centers in the far South are divided by two. As in the first illustration, the territory selected tends to emphasize the Southwest, resulting in favor of St. Louis. Had the large cities in Wisconsin, Minnesota, and Michigan been included, the balance would have gone to Chicago.

City or center	Population	Product of population and freight rate, from			
		St. Louis	Chicago	Kansas City	Indianapolis
Atlanta, Ga.	196,144	3,087	3,762	4,351	3,391
Birmingham, Ala.	189,716	2,850	3,572	4,113	3,173
Chicago....	2,547,201	14,478	0	25,400	14,351
Cincinnati, Ohio	414,248	2,726	2,624	5,801	1,824
Dallas (Texas Group).	500,000	9,200	10,450	9,200	10,550
Denver (Colorado Group)	400,000	8,100	9,000	5,760	10,560
Des Moines, Iowa	104,052	715	750	750	1,125
Indianapolis	283,622	1,722	1,502	3,822	0
Kansas City District.	407,912	3,000	4,000	0	5,460
Little Rock, Ark	58,716	750	900	825	915
Los Angeles, Cal	536,485	21,862	22,525	19,875	24,187
Louisville, Ky	240,808	1,510	1,596	3,300	1,098
Memphis, Tenn	151,877	1,222	1,597	1,518	1,485
Mobile, Ala..	59,201	675	825	864	780
Nashville, Tenn	118,136	1,050	1,506	1,848	1,254
New Orleans, La	377,010	4,275	5,225	5,472	4,940
Oklahoma City	97,588	1,625	1,875	1,190	1,900
Omaha, Neb	177,777	1,350	1,800	1,350	2,457
Peoria, Ill	72,184	339	318	612	413
St. Louis District	1,070,000	0	6,099	8,025	6,580
Springfield, Ill	62,623	237	288	525	354
Wichita, Kan	89,201	1,237	1,462	742	1,791
Springfield, Mo	40,341	310	410	246	556
Davenport, Rock Island, Moline	104,860	535	495	750	690
Tulsa, Okla	70,000	1,008	1,183	745	1,242
Pine Bluff, Ark	40,000	500	600	550	610
Shreveport, La	36,000	626	726	626	736
Totals	8,424,702	84,989	85,170	108,260	102,422
Reference factors	....	100.8	101.1	128.5	121.5

Four places of figures are omitted from each product in the table.

The term "fabrication in transit," as used in the foregoing discussion, is not to be confused with the arrangement termed "milling in transit," as employed in the flour milling business. By a special arrangement with the railroads a car of wheat may be stopped at a designated point, and the wheat converted into flour and other wheat products, reloaded on the car, and con-

tinued on its way to market under the regular through freight rate that would have applied had the wheat gone on undisturbed to the same destination. This is an entirely special provision, aimed at the building up of a decentralized milling industry.

Special Exercise for Solution

A marketing system is to be laid out for a manufacturing plant to be located at X. The product may be taken as any one of those named in the list below. The plant is to employ about 300 persons, and is modern in every respect.

Product: *a.* Paper boxes and cartons, including standing boxes for candy, shoes, and the Christmas trade; nested ice cream cartons; flat boxes and cartons for butter packages, suits, milliners' goods, etc.

b. Furniture of the kinds indicated in the first of the illustrations on distribution factors above.

c. Farm tractors.

d. Cotton and leather-faced working gloves.

e. Trunks and miscellaneous leather goods.

f. Special hardware, including simple tools, such as wrenches, pliers, ammers, cold chisels, punches, nail sets, etc.

Assume the duties of a sales manager and lay out a plan from the beginning, deciding as to relations with jobbers and retailers, and special agents. Consider such questions as the use of demonstration and exhibit rooms at selling centers, use of the mails, and promotion of activities which would stimulate business in the trade territory.

Lay out a marketing territory in sketch map form to include some district that is familiar to you. Indicate the important centers and the shipping routes. Estimate the business at each center, basing this on your knowledge of conditions in the sections where you are acquainted. Write up the plan in report form ready to submit to the company officials.

CHAPTER IV

FUNCTIONAL DESIGN OF THE ENTERPRISE

In the carrying out of the scheme of production we have seen that there are performed the functions of *design, operation, equipment, comparison, material, sales,* and *control.* The first has been considered in its general features of fixing the type, grade, and adaptability of product to the needs of the market. The physical appliances and working personnel for realizing these standards will be provided in the plant and organization, as items in operation and equipment. It is the aim of this chapter to deal with the general plan for the operation and equipment functions, in accordance with which the physical plant must be established. In other words, we are to discuss the process of manufacture.

Most of the existing treatises on industrial engineering and management deal almost exclusively with metal working plants. This is natural, as such plants offer especially marked opportunities for the development of betterment processes. In them the individual workman exercises a dominating influence upon the character and quantity of product. Skill in handicraft there counts for a great deal, and the training of the worker is an important matter. The flow of material through the plant is conditioned by the human factor, in large measure, while in many other types of enterprises it is fixed absolutely by the rigid laws of equipment. But for a full understanding of industrial demand a more general treatment of manufacturing processes, covering a wider range of the major activities in the commercial system of the present day, is desirable. In all of these activities the need for the services of the technical expert is being felt as the demand for economic production increases.

Carrying out the functional design involves two steps: first, making the general analysis of operating conditions to show the main factors of capital investment, amount of raw material, number of employees, and power demands with the money values represented by each, and so estimating the income and expenditures for a hypothetical establishment; second, making the detailed

analysis of plant equipment required to carry on the proposed enterprise. Several typical industries will be given consideration on an illustrative basis. The data given will not be complete and will not serve to replace experience, but will suggest methods to be followed in the general design.

THE METAL WORKING INDUSTRY

This group of activities, about which so much has been written, will be treated first. The principles involved apply to many industries commonly separated in the census reports, such as "foundry and machine shop products," "electrical machinery," "locomotives," "agricultural implements," "cutlery and tools," "automobiles," "sewing machines," "stoves and furnaces," "typewriters," and "cash registers and calculating machines." Considered in total, the group represents a large portion of the organized manufacturing enterprises. In it are met the most complex problems of the plant designer, because the human element figures more prominently than in most of the others, and the material is subjected to a series of manipulative processes which make necessary the utmost care in routing, close studies of machining methods, and a maximum of orderly recording of cost elements to insure accuracy in financial control. It also presents the greatest opportunities for the development of standardized practice in quantity production. It is the distinctive synthetical industry.

Proceeding with the general analysis of operating conditions, the averages of the production factors given in the table in Chapter II for the ten industries just listed are as follows:

Employees per $1,000 added value	0.838
Wages for the same	$ 566.70
Capital for the same	$1,943 00
Power requirements for the same, horsepower	1 116
Ratio—added value to value	0 63
Value of products = 1,000 ÷ .630 =	$1,586

Reducing to the basis of one employee, these figures become—wages $675; capital $2,315; power 1.33 hp.; cost of materials $700; and value of product $1,890.

It is important to find the weight of product, in approximate terms, as an index of the amount of work handled. To do this, the value per pound must be estimated, understanding that

these data are on the basis of pre-war conditions. For the wide variety of articles included in these ten groups the value per pound varies greatly, from about 8 cts. for the simpler machinery to 50 cts. and even more for the more complex, and especially for the high-class patented articles, like cash registers and calculating machines. Allowing for the much greater tonnage of the lower class commodities, a value of 12½ cts. per pound will be used, which gives 15,120 lb. as the weight of product per employee per year. Such a figure must be used with caution, however, will full allowance for variations when dealing with the several special classes of metal products.

The weight of raw materials employed will be from 10 to 20% greater than the product. Some of the process materials are not present in the finished article, and loss occurs in the machining processes.

The next step is to proceed with adjustments to present price and wage conditions. It may be taken for granted that the weight of material handled and power requirements, per employee, will not vary materially. Wages, cost of material, value of product, and required capital investment will vary notably with economic conditions. As a check on these items, the following calculations from the advance publications of the U. S. Census for 1919 will be of value, but it is to be borne in mind that conditions in that year were at the height of the extreme fluctuations that took place immediately following the World War.

In the returns for the state of Massachusetts the average of the four products—automobiles, cutlery and tools, electrical machinery, and foundry and machine shop products—shows, as amounts per employee:

Wages	$1,212
Cost of materials	1,475
Value of products	4,125

The machine tool industry for the entire country shows:

Wages	$1,240
Cost of materials	1,112
Value of products	4,000

In the manufacture of engines of all kinds the figures are:

Wages	$1,345
Cost of materials	2,820
Value of products	5,980

In the building of locomotives, in the establishments other than railroads:

Wages	$1,450
Cost of materials	2,550
Value of products	5,850

Agricultural implements manufactured in Ohio give:

Wages	$1,150
Cost of materials	2,550
Value of products	5,380

The amount of capital appears to run approximately with the cost of materials—namely, from $2 to $4 per dollar of material. It may be noted that for the above summary based on the 1910 Census the capital figure is $3.30 per dollar of materials cost.

Somewhere between the two extremes will lie the figures applicable to the current period, 1922 to 1924. Since 1920 the drop in iron and steel has been markedly more than the reduction in wages, so that the relatively high cost of materials shown in the 1919 figures, compared with wages, has been largely reduced, with corresponding effect on value of product. This may not be true for the machine tool industry, where it would appear that conservatism in buying, with the using up of existing stocks, kept down the amount expended for material in 1919. The latest data exhibit a tendency toward the employment of power in greater proportion, the average demand standing at about 2 hp. per employee in place of the 1.33 hp. obtained from the earlier reports.

For application to the average establishment in this group, the following set of values may be used, wherein the wage scale is set 20% below the 1919 figure, and materials one-third less. The work based thereon is to be understood as being illustrative only, however. It is not necessary in the present juncture to assign a value of product. The weight of material may be taken as constant, at 7½ tons per year per employee. For such reference purposes the following figures are fairly representative:

Wages[1]	$1,015
Salaries of officials and clerical force, 30% of wages	$ 305
Materials, for 15,000 lb. of product	$1,315
Power, capacity of equipment, horsepower	2
Annual cost of power, independent plant, exclusive of labor, $28 per horsepower	$ 56
Capital, $3 per dollar of cost of materials	$3,945

[1] Based on maximum number employed. Average earnings will be greater.

It is to be understood that in this classification "materials" includes all supplies used in plant and office, including fuel used for process purposes, in addition to true raw material consumed.

APPLICATION TO MACHINE TOOL MANUFACTURING

In making application to any line of work, any known characteristics of that line should be given consideration. Hence in this case figures will be used differing materially from the average figures in the summary just given above. For these figures, the author is indebted to several manufacturers of the Cincinnati district, but they do not apply to any individual company. It will be noted that they conform in most essential respects to the relationships developed from Census reports.

A plant will be assumed equipped to employ 500 men in all producing departments, including foundry, but exclusive of the office and sales staff, and which in a normal year will average about 425 men actually at work. The product is a high-grade engine lathe which has a wide sale among first-class metal working plants in all parts of the country, and which is furnished in a large range of sizes both as to swing and length of bed, and with a variety of speed adjustments and power drive systems. The latter conditions make necessary the carrying in stock of many finished parts, ready for assembly in accordance with orders, calling for considerable working capital. The plant is commodious, well lighted, and effectively organized and managed. The equipment is modern and includes a few machine tools of unusual size to accommodate long lathe beds that are built occasionally for turning heavy naval guns and other long work. This means a heavier investment in plant than would be required for building a more closely standardized line of tools.

The total annual value of product, taken as the actual cost, including general office expense but no profit, may be taken as 31 cts. per pound. The output in a typical year amounts to $1,475,000. This means a finished product weight of 4,750,000 lb., or 11,900 lb. per employee.

The investment will vary with location as influenced by value of land, building costs, etc., but may be taken as follows:

Land	$ 35,000
Buildings, including railway sidings	237,000
Equipment complete, including full complement of small tools, all materials handling appliances, office furnishings, and auto and truck transport	742,000
Total plant	**$1,014,000**

Current inventories considered constant for steady operation:

Raw material	$ 85,000
In process and finished goods	536,000
Cash on deposit	25,000
Total current	$ 646,000
Total investment	$1,660,000

In later calculations it is assumed that $500,000 of this investment is represented by 5½% bonds.

The operating account for an establishment of this size may be estimated in advance only in round figures. The most difficult to predict is the amount for material which is not consumed directly in the process, in which category come a multitude of articles purchased for the general conduct of the business and upkeep of the plant. Under the heading of "material" all articles purchased will be included, as in the Census enumeration, some of which might properly be charged against maintenance.

The basic estimate is for the weight of iron castings. This is done by using the formula commonly employed by machine tool builders, whereby

$$\text{Weight of product} = \frac{\text{Castings} \times 0.90}{Z},$$

where Z is the percentage of castings in the finished machine and 0.90 is the net weight of castings after machining, on the basis of removing 10% of metal. For high-grade engine lathes Z equals 0.93. For turret lathes it is 0.95. For other forms of tools it will vary somewhat, but not far from these limits.

Solving for "castings" in this formula, with $Z = 0.93$ and a finished product weight of 4,750,000, gives a weight of 4,900,000 lb., or 2,450 tons per year. Foundry materials may then be calculated from this tonnage output.

It is adopted as good practice to employ cast steel gears in the change-gear transmission used to drive the lead screw. These castings will be purchased. Machinery steel and brass make up the balance of weight. It is understood that for cone-head lathes the overhead jackshaft, with cone and drive pulleys and hangers, is included with the finished machine. Taking the weight of an 18-in. by 10-ft. lathe as 3,450 lb., and this as an average of the total built, the number of lathes turned out per year is 1,380. Hence for each pound of steel casting, brass, or other part other than cast iron employed on a single lathe,

there will be required 0.69 tons of the metal per year. This affords a ready means of estimating the material to be purchased, adding 10% as metal removed in the machining process.

Material cost may now be estimated as follows:

In the foundry, including new pig iron and steel scrap, special alloy metal, flux, sand, loam, core material, and miscellaneous		$ 109,700
Machinery steel, 166 × 0.69 × 1.10 × $91 =		11,520[1]
Steel castings, 35 × 0.69 × 1.10 × $165 =		4,380[1]
Brass, 15 × 0.69 × 1.10 × $207 =		2,360[1]
Fuel, coal and coke, 1,250 tons at $7.50 =		9,375
Oil, lubricant and cutting fluid		2,500
Small parts purchased, including bolts, etc		2,500
Lumber, for patterns, flasks, crating, and miscellaneous:		
5 M at $150	$ 750	
40 M at 60	2,400	3,150
Paint and finish material, for machines and for miscellaneous use		5,000
Forge shop fuel and supplies		4,000
Tool steel		8,000
Heat-treating equipment, supplies and maintenance		2,500
Spoiled material, 10 tons at $90		900
Safety appliances, new and upkeep		2,000
Material transport, upkeep and new, cranes, hoists, trucks, etc.		6,000
Upkeep of plant equipment, chargeable to maintenance but taken as parts and material purchased, take 1½% of $600,000		9,000
Upkeep of buildings, taken as before		3,600
Special improvements and replacements		15,000
Upkeep of tool room equipment, replacing worn tools, files, grinding wheels, lost gages, scales, etc		15,000
Plant service—heating plant, light and power lines, telephone, belting, general supplies		10,000
Research and inspection service		15,000
Compressed air service, tools, etc		5,000
Stock room and storage—upkeep and extension		5,000
Office and drafting room supplies, new files, furniture, fixtures, and miscellaneous		20,000
Personal service—medical supplies, recreation, lunch room, books, etc		15,000
Outside transportation—trucks, automobiles—supplies and depreciation		25,000
Replacements of equipment, chargeable to depreciation but actual purchases only		25,000
(Regular depreciation considered later)		
General and miscellaneous supplies		40,000
Total		$ 381,480

[1] Note: Items of machinery steel, steel castings, and brass are based on each lathe having 166 lb., 35 lb. and 15 lb. of those metals respectively.

Labor, operating plant only, 425 men, 2,500 hr. per year, at 62 cts.		657,750
Office, sales, and clerical service, taken as 30% of wages		197,325
Power and light, purchased, 350 kw. maximum demand, 80% load factor, $1\frac{1}{2}$ cts. per kw.-hr., 2,500 hr	$10,500	
Extra lighting in off hours	2,000	12,500
Freight and express on miscellaneous account		10,000
Interest on bonds, assumed $500,000 outstanding at $5\frac{1}{2}$%		27,500
Depreciation:		
2% on $200,000 building	$ 4,000	
4% on 600,000 equipment	24,000	28,000
Insurance—1% on $1,000,000		10,000
Taxes—$1\frac{1}{2}$% on $800,000		12,000
Sales expense, exclusive of services		20,000
Total operating expense		$1,356,555

The total output was assumed at the start to be on a cost basis of 31 cts. per pound, amounting to $1,472,500. This means that this year's operation shows a margin of $115,945. Actual sales would be based on a figure sufficient to yield a satisfactory dividend payment on the outstanding stock investment of $1,160,000, and also to guard against possible shrinkage of value on the heavy inventory carried. If 20% were considered sufficient to meet these two needs, it would mean a sale price of 37.2 cts. per pound of finished net weight of product.

This analysis has been carried through in considerable detail for the purpose of bringing out the manifold items that enter into the operating expense of a large or medium-sized establishment of this type. Others to be considered will be taken on a much more condensed basis.

APPLICATION TO HEAVY ENGINE BUILDING

A Diesel oil engine, which may be taken to typify this class of manufacturing, shows the following characteristics. It is built according to standard designs, mainly on an order basis. By varying the number of cylinders, a wide range of capacity may be secured with a small number of cylinder sizes. Power of units built will vary from 150 to 1,000 hp., averaging 500. The weight per horsepower, taken from actual figures of a prominent manufacturer, is 440 lb. A plant will be taken equipped to turn out

10,000 hp. per year, or twenty average engines. The analysis will assume a year of maximum production, which should thus be expected to show a surplus of considerable proportions.

The plant includes an iron foundry for its own work, but purchases all forgings, steel castings, and brass. Materials will thus show a high value per pound, some of the forgings being massive and complex in form. Plant equipment will not have to provide for the features of mass production which entered into the machine tool establishment, but there will be several large machines. The erecting force will be larger in proportion, and must include men of skill, both for the shop assembly and for erection in purchaser's plant. Inventories will be relatively low, omitting finished parts in stock. The ratio of capital investment to material cost, which was 4.24 in the machine tool plant, will here be taken as 2.40. While this may seem small, it is to be remembered that material cost here is high because of the expensive forgings purchased, as noted above.

STATEMENT OF OPERATIONS

Weight of product, 440 × 10,000 = 4,400,000 lb.	
Weight of direct materials, on basis of 10 % loss in machining, 4,400,000 ÷ 0.90 = 4,888,888 lb.	
Cost of material, item including all purchased of both direct and indirect articles, small tool replacements, etc., as per experience of builders, at rate of 11.09 cts. per pound	$ 540,000
Number of shop employees, including erectors, from actual experience	255
Material, direct, per employee, tons	9.6
Wages, basis of 62 cts. per hour in machine shop and 58 cts. in foundry, weighted average 61.4 cts., 2,500 hr. per year.	$ 391,400
Salaries, officers and clerical, 25 %	97,850
Power, basis of 2.45 hp. installed per employee, 80 % of this for maximum demand and load factor, 66.7 % of this, at cost of 2 cts. per kilowatt-hour 255 × 2.45 × 0.80 × 0.667 × 2,500 × 0.02 =	16,750
Depreciation, 5 % of $500,000	25,000
Insurance, 1 % of $700,000	7,000
Taxes, 1½ % of $600,000	9,000
General repairs and maintenance	10,000
Miscellaneous overhead	10,000
Sales expense, excluding service, 10 %	143,600
Total, factory cost plus sales, equals $125 per horsepower	$1,250,600
General office expense, excluding salaries	15,000
Total cost	$1,265,600

Interest and dividends, basis of $500,000 6% bonds and $790,000 outstanding stock:		
$500,000 × 0.06	$	30,000
$790,000 × 0.10		79,000
Total		$1,374,600
A selling price of 20% over factory cost yields a gross income of		1,500,000
Surplus on year's operation	$	125,400

APPLICATION TO GENERAL METAL PRODUCTS PLANT

A partial analysis is given for a concern engaged in the manufacture of a line of miscellaneous goods, including hoisting, conveying, and materials handling machinery, power transmission appliances, crushers, and general structural steel work. The figures are averages of data secured from two similar plants of about the same size, each employing approximately 500 men in the production department. The output has a value per pound one-half of that for machine tools and is taken as 18 cts. In this class of product the material cost is about 55% of the total value. Wastage of material is greater than for the other types. Sales cost is relatively high. Designing assumes greater place in the cost, since many isolated orders of special character are taken. Investment figures are not available, but, as compared with the engine plant treated above, the difference is not great. In this item the values on buildings and permanent equipment will be less but inventories on raw materials higher.

PARTIAL STATEMENT OF OPERATIONS

Weight of product, per year	18,850,000 lb.
Weight of product, per employee	18.85 tons.
Value of product, at 18 cts. per pound	$3,393,000
Cost of material, this including the many items purchased as listed in the preceding applications, 55% of value of product	1,866,150
Labor, shop force only, scale of 55 cts. average, 2,500 hr. per year, 500 men	687,500
Designing, and erecting force on the road, 50 men, average $150 per month	90,000
Officials and clerical salaries, 25% of the shop wages	171,875
Power, from actual record, 46,500 kw.-hr. per month, taken at 2 cts.	11,100
Total of items listed	$2,826,625
Balance to cover fixed charges, sales expense, and profit	566,375

FUNCTIONAL DESIGN: SECOND STAGE

In the second stage of the functional design as applied to metal working plants, attention is centered entirely on the special articles to be produced. The analysis of the operating conditions is presumed to have been made according to the methods just outlined, so that a good idea has been secured of the amount of material to be handled, the number of persons employed, and, in a partial degree, of the space requirements. It is to be assumed, also, that the designer knows the extent to which improved management methods are to be employed, so that he is able to give intelligent attention to space needs for planning and other service departments.

The man who does this designing must be well acquainted with all of the processes of manufacture. He must also be competent to analyze equipment demands on an economic basis. To specify operating machines for specialized process steps for which there will be but small demand, when the work in question might be performed on another machine of more general service, may result in adding equipment of high cost, which will add heavily to overhead charges, out of harmony with plant effectiveness. He must aim to produce a balanced equipment, consistent with the scale of the enterprise.

The work involves four distinct steps, as follows:

1. Making the detailed analysis of the articles to be manufactured, which means listing every part with a specification of the process steps to which it is to be subjected.

2. Selecting the tools required in the performance of these process steps, and making a time estimate for the work and a schedule of operations.

3. From the preceding, to prepare routing diagrams that shall determine the arrangement of tools in the plant, from which space requirements follow. In performing this work conventional drawings should be made that are purely diagrammatic, showing the advance of each piece from tool to tool and the points where the several pieces meet in any pre-assembly steps.

4. Listing the requirements as to special fixtures, jigs, etc., and estimating the tool room facilities needed to care for the shop routine.

When the preceding has been accomplished, the actual planning of the buildings begins. In this, in addition to provisions for the equipment covered by the prepared lists, the attendant

needs for storage of materials, assembly and testing space, shipping facilities, materials transportation, space for stock handling and issuing; office quarters for recording, costing, planning, and administration, and suitable quarters for sanitation and special needs of the personnel must be given adequate attention. Plant service demands for light, power, heat, ventilation, and general caretaking come in for consideration at the same time. Well-developed plans are called for that will show to scale all the demands of operation and service, and which form the basis for the design of the physical plant that is to follow.

Space is not taken for an elaboration of the various steps indicated above. An excellent guide, suggestive on many points, is the work of Charles Day on "Industrial Plants," published by the Engineering Magazine Company of New York. Another that will be found useful is Parkhurst's "Applied Scientific Management," published by John Wiley and Sons. In Chapter V the details of plant design are discussed more fully.

Modern ideals in the administration of industrial enterprises find their most complete expression in metal working plants. This is so largely because the factors of labor and equipment are here combined in a vital manner, with labor in control of equipment. The human element is the more significant, but it cannot attain its proper standards unless equipment is adjusted logically. Much has been written on management and efficiency, but the proper point at which to begin in the process of betterment is right here on plant and process fundamentals. Tools must be selected wisely, and wisely placed. Materials must move freely and without unnecessary crossing of traffic lines. System and order in the arrangement of tools and in the movement of materials betoken a well-ordered management, and the same qualities in men. In no other phase of managerial activities will results flow so freely from expended effort, or meet with such unquestioned approval. Manufacturers have far to go to produce plants that will equal individual machines in the scale of perfection. Engineers and designers have produced marvelously effective machine tools, but they have not progressed so far in producing effective plants. Their vision must now be broadened to embrace the idea of the plant as a working unit—a machine whose smooth operation is a primary requisite to economical production.

IRON AND STEEL

Considered with its two main divisions—blast furnaces and steel works and rolling mills—this is the largest single industry in the country. In 1919 the capital employed was 7.75% of the total for all industries, amounting to $3,458,934,958. It is basic to many other established groups. Whatever affects it, involves every other activity which uses equipment of the machinery sort, and this means all.

Iron and steel manufacturing is a characteristic synthetical industry, chemically.. The main portions of the physical plant are devoted to manipulative processes, however, and it is with these phases that we are concerned, primarily. Design of plant and equipment has to do with the movement of material, first the ore, fuel, and flux through the blast furnace; thence to the steel furnaces, ingot molds, reheating pits, rolling mills, cutting and trimming machines; and thence to storage and the shipping platform. After the final proportioning at the furnace the work is manipulative, calling for transporting facilities of high capacity and exact adaptation to the specialized needs. Only the general features may be dealt with at this time.

The following are the principal financial characteristics, based on the 1919 Census:

Item	Blast Furnaces	Steel Mills
Value of products	$794,466,558	$2,828,902,376
Added value	$173,180,062	$1,148,326,618
Capital	$802,416,541	$2,656,518,417
Added value per $1,000 value	$228	$406
Wage earners per $1,000 added value	.29	.327
Value of product per employee	$19,050	$7,540
Wages per employee	$1,760	$1,700
Power per employee, horsepower	38	10 2
Capital per employee	$19,250	$7,075
Capital per dollar of material	$1 29	$1 58

It will be observed that these values differ materially from those cited in the preceding section for the various metal manufactures. For the blast furnace branch, especially, capital and value of product per plant employee are high. If values per ton applying in the year 1919 be taken as $45 for pig iron and $83 for steel, the above figures show the tonnage of product per employee to be 424 for the blast furnace branch and 91 for steel. This means that labor has been reduced to low figures in operation procedure.

The large part played by equipment is indicated by the very large figures for power used per employee. Wages are high, in which connection one must remember that working conditions call for a 12-hour day on a two-shift per day basis in those branches demanding continuous operation.[1]

To make an approximate estimate of conditions existing in the latter part of 1922, we may take pig iron at $28; steel averaging at $63; material less than at the end of 1919 by 24%; and capital reduced by 10% to cover the reduction in that part represented by inventories of materials and stock on hand. The production per employee was probably somewhat less in 1922, by reason of the lessened scale of business, but the difference is difficult to estimate with the data obtainable. Applying these corrections we have:

Item	Blast Furnaces	Steel Mills
Value of product per employee	$11,850 00	$6,730 00
Capital per employee..	17,325 00	6,367 00
Capital per dollar of material	1.65	1 87
Wages per employee, 80% .	1,408 00	1,360 00

The Blast Furnace Branch

Under the specification set by the chemist or metallurgist, the operation problem is mainly that of handling materials. Routing of material is fixed by construction of the plant, and materials must move in exact conformity with the quantity factors determined by process. Under good standard conditions every ton of iron produced calls for about 2 tons of ore, ½ ton of limestone for flux, 1 ton of fuel, and 4 tons blast (air). The outgoing items are the ton of iron, ½ ton of slag, and 5½ tons of blast, the last in the form of a gas valuable as fuel and used in the power plant. For a 500-ton furnace this means handling daily, for long continuous periods, about 1,750 tons of solids, 750 tons of white-hot liquids, and 4,750 tons of gases.

To accomplish this there must be provided: storage for materials in amount sufficient to meet demands for periods depending on transportation of the supplies, which means for several months in the case of ore moving by lake steamer where traffic is held up by cold weather in winter; means for handling the raw materials

[1] Recent changes in the policy of the steel industry respecting the 12-hour shift will modify these figures.

locally in charging the furnaces with proper mixture; compressors and heaters for the air blast; piping to take away and purify the gas from the furnace; means for handling the melted iron as it flows from the furnace, either ladle cars when the iron goes directly to the steel mill, or pig molding machines when the iron goes to the general market; means for handling and disposing of the slag; and a water supply system for cooling purposes. The meeting of these demands calls for both mechanical engineering skill and administrative control of a high order. Achievements in both lines have been notable. Under the pre-war conditions, ore was unloaded from lake carriers at a cost of 4 cts. per ton. Labor cost at the furnace plant was down to 50 cts. per ton of iron produced. Changed wage scales have increased these costs slightly. Power equipment has been brought to the highest degree of excellence. Rotary air compressors, turbine driven, are applied successfully. Electric power is used exclusively in modern plants for handling and hoisting materials.

For an accurate and complete description of the equipment and methods employed, the reader is referred to Johnson's "Blast Furnace Construction" (McGraw-Hill), an excellent treatise on the subject.

THE STEEL MILL

The steel making plant and the rolling mill may form quite distinct sections of the establishment, operated as separate enterprises in respect to control and accounting. The steel is molded to ingot form in the former, and if placed on the general market will be rolled into billet form in a "slabbing mill." The rolling mill has its "soaking pits" for reheating the billets preparatory to rolling to commercial forms. The billets coming from each furnace "heat" are marked so as to identify them for comparison with the record of the charge and chemical analysis of the same. This is of importance in case defective material must be traced.

In steel making, as at the blast furnace, handling of material is the principal feature in operating, outside of the fundamental work of proportioning and testing performed by the chemist. The iron may come in molten state from the blast furnaces in special ladle cars or in solid form. For charging the furnaces, traveling cranes of 5 to 75 tons capacity handle the ladles. Small

cranes, 5 to 10 tons, handle the scrap charge and carbonizing ore from the charging floor. At the pouring side, using figures for the Indiana Harbor plant as described in *The Iron Age* of July 10, 1919, two 150-ton cranes handle the ladles, which run as large as 100-ton capacity each. In this plant there are ten 90-ton basic open hearth furnaces, operating with oil or tar fuel. At each furnace there is installed a waste heat boiler, utilizing the hot gases on their way to the stack. A turbine-driven fan at the base of the stack serves to draw the gases through the boiler to prevent choking of the flow away from the steel furnace. These details are mentioned here, not as embodying a description of the steel making process, but simply to suggest the types of problems that the engineer must meet to handle the never ending stream of metal moving on its way to the rolling mills, and to effect every possible saving in fuel and labor.

In America the trend of practice has been to reduce labor, usually at the expense of power for the machinery equipment. This is consistent with conditions here, where labor is high and fuel cheap, whereas in European countries fuel is high and labor cheap. It is not certain that these relations will continue in this country if present fuel prices are an indication. The utilization of waste heat in the boilers referred to is a step of comparatively recent times, and marks the heat economizing measures that will characterize improved operating practice of the future.

The building in the Indiana Harbor plant housing the 10 furnaces, together with a 600-ton molten metal mixer employed in preparing the charges, is 1,000 ft. long. The building housing the main mill, a 40-in. machine, is 920 ft. long. This gives an impression of the magnitude of modern plants.

In the rolling mill branch of the work the points of chief interest are the rolling mills themselves, the driving power employed, and the handling of the stock from the billets in the soaking pits to the storage of finished material ready for the market. Up to recent years the heavy rolls were driven by reversing steam engines, cross-compound or twin. The reversing electric motor has since been developed, so that machines of several thousand horsepower capacity, capable of reversing from full 40 r.p.m. ahead to 40 r.p.m. opposite in 1½ sec. can be secured. From the large mill performing the first rolling operations, the lengthened billets pass to the smaller finishing rolls, operated by small motors.

In variety and intensity of work, a modern steel plant presents one of the most complex problems in production. The insistent demand for results in moving material tends to dull the mind to calls for economy, save as increased production results in lower unit cost. Performance records are of the utmost importance. Such records constitute the practicable check on the movement of material. Plant designers have striven to coördinate capacity of furnace, capacity of rolls, and capacity of handling machinery. It is necessary to know where retardation comes, if at all, and performance records give the necessary data.

Although labor has been cut to a minimum in this country, the human problem in the steel industry is acute. The work is strenuous in a trying atmosphere. Hours of work are long at best. Operation must needs be continuous, 24 hr. per day and the full 7 days per week. Labor cost runs low as compared with value of product, a fact that tends to cause unrest. This phase of administration demands an important place in the program of the executive.

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PORTLAND CEMENT

Portland cement manufacturing is a synthetic process with chemical base. To appreciate the problems of operation and equipment, the process must be understood in its general features.

The usual materials are limestone and shale. Certain other rock is found containing the important elements, notably marl, while alkali wastes, blast furnace slag, etc., make good material.

The chemical elements of the raw mixture that are of primary importance are calcium carbonate of the limestone, silica, supplied mainly by the shale, ferric oxide, supplied by both, aluminum oxide, supplied mainly by the shale, and magnesia, coming largely from the stone. The proper mix is calculated from the analysis of the materials to give proportions of approxi-

mately 62% calcium carbonate, 22% silica, and 8% alumina, with other elements in small proportion.

From quarry and shale pit the materials are brought in small cars to the crusher plant and there pulverized in ordinary crushers. After this, they usually are mixed according to formula. At this point storage is commonly provided, so that from here on the plant may run continuously, 24 hr. per day, made necessary by the loss occasioned by stopping the kilns, while the quarries are operated on the 8- to 10-hr. day plan. The mix goes through the dryers (mixing may be done after drying if moisture content varies) and then to the raw grinders. Two methods are employed in the raw grinding, some using the dry and some the wet process. The latter seems to be gaining in favor. Ball and tube mills are employed in the wet process, the first coarse grind being made in what is called a Kominuter, a form of ball mill. In the dry process the Griffin mill is often used in the raw mill.

The finely ground material now goes to the slurry tanks (wet process) where it is mixed with more water and agitated to secure complete uniformity of product. From there it is fed to the upper end of the kilns, which are cylinders, usually 8 ft. in diameter and 100 to 150 ft. in length, set in an inclined position, lined with firebrick and slowly rotated. Here the material is burned to a hard clinker, which drops from the firing end of the kiln into coolers which are smaller rotating cylinders, perhaps 6 by 60 ft., through which cool air is passed. From the cooler the clinker goes to storage tanks by bucket conveyor, and thence to the finish grinding. Tube mills (large rotating cylinders containing flint balls) and Griffin mills are used. Belt conveyors are commonly employed to carry the finished product into the storage space for sacking and shipping. Because of variability in marketing, due to seasonal demands, large storage is necessary.

An important adjunct is the fuel mill, where the coal is powdered. In certain localities natural gas has been available as fuel, but this is passing and all standard work must be based on coal. The coal is first crushed, then dried in a small cylindrical dryer, and finally ground in a mill similar to those used for the clinker. A screw conveyor is an effective means for moving the powder from the grinder to the burner. The burner operates by compressed air, which blows the coal in a jet into the lower end of the kiln and at the same time mixes the air and coal particles so that combustion is rapid with high temperature rise.

Space is not given here to accurate descriptions of the equipment, but the reader is referred to an excellent book for this—Eckel's "Cement, Limes, and Plasters" (Wiley).

The leading problems in cement plant construction and operation are the following:

Movement of raw material from quarry and shale pit. In some locations topography permits gravity movement of the limestone. Outdoor operations difficult at times.

Selection of raw mill equipment. Opinions differ as to the wet and dry methods, as regards quality of cement produced and economy in burning. Wet process was assumed in above statements.

Kiln operation; lining and fuel problems; economy through installation of waste heat boilers in dry process.

Power development economics. Power is used in large amounts. Electric motor drive now common throughout mill.

General maintenance and repair. Wear on many parts of the equipment is excessive. A well-equipped repair shop is necessary, wherein is opportunity for effective system in shop management, often neglected.

Transportation, both in the plant and outside. Incoming coal and outgo must be balanced with storage.

Labor conditions demand attention, but usually are not serious. The process is not as sensitive to the touch of workers as is steel making.

Dust conditions are bad for workers, calling for attention.

Plant records of process steps in production are of simple character, due to this being a single-product enterprise. A failure in any department at once shows up by effectively stopping progress in the next, so graduated adjustments are impossible. Material must move at a fixed rate. For the same reason, cost accounting is a simple matter of bookkeeping, without any problems on distribution of expense, except as between different departments.

Control of quality—a technical matter mainly chemical, involving the mix, kiln temperatures, grinding, and admixture of gypsum to retard the set.

The preliminary design of a portland cement plant involves matters which were discussed briefly in Chapter III. With the marketing question settled favorably, there must follow a careful study of the supply of materials. It is an industry that is bound

in location to the source of materials, limestone and shale, or blast furnace slag, as the case may be. If the former, a favorable site is one so placed that the stone will pass to the mill by gravity. Topography is, therefore, an important consideration. Fuel supply follows as an element of significance.

The balance of production factors, according to the 1919 Census returns, is as follows:

Value of products	$175,261,910
Added value	$ 95,755,110
Capital	$271,269,250
Added value per $1,000 of value	$540
Employees per $1,000 of added value	266
Value of product per employee	$6,860
Wages per employee	$1,300
Power per employee, horsepower	19 2
Capital per employee	$10,600
Capital per dollar of material	$3 11
Quantity of product, at $2 per barrel	87,609,000

The following figures are fairly representative of construction and operating costs for a modern mill of daily capacity of 2,500 bbl. The site referred to is one where limestone and shale occur in superimposed strata, so placed that movement of most of the material to the crushing mill can be effected by gravity.

Land		$ 25,000
Development of site		15,000
Water supply		27,000
Temporary structures		10,000
Quarry equipment, including haulage		40,000
Buildings: estimated on basis of simple steel construction with inside walls plastered on metal lath, except cement storage, which is solid concrete, and office building of brick:		
Office building	$ 30,000	
Cement warehouse	100,000	
Main mill, 120 by 330 by 30	65,000	
Finish mill, 60 by 160 by 30	27,000	
Mixing and drying mill	27,000	
Crushing plant	7,200	
Power building	35,000	
Coal plant, storage and pulverizing	22,500	
Machine shop and plant office	18,000	
Connecting structures	2,800	
Quarry houses	2,500	
		$ 337,000

Main process equipment:		
6 Kilns, 8 ft. by 125 ft.	$ 76,800	
Kiln linings	7,200	
Raw mills (Kominuters)	36,000	
Finish mills:		
Tube mills	33,600	
Griffin mills	25,600	
(Last item includes coal mills.)		
Ball mills	28,000	
Rock dryer	4,000	
Coal dryer	3,200	
Clinker coolers, 2	7,200	
Rock crushers	6,000	
Coal crushers	1,000	
Elevators and conveyors	7,600	
		$ 229,200
Installation		40,000
Foundations and special construction		50,000
Power plant equipment, 2,000 kw. at $150		300,000
Temporary power during construction		15,000
Electric motor application		75,000
Machine shop equipment		35,000
Miscellaneous mill and office equipment		30,000
Contingent, 5% of equipment and construction		55,000
Engineering and supervision, 6%		66,000
Changes during adaptation period		75,000
Organization expenses		15,000
Interest during construction		50,000
Total cost		$1,489,000

OPERATING EXPENSES, ANNUAL

Labor:		
Quarry, 28 men	$ 33,600	
Main mill and power, 95 men	128,250	
Extra kiln and power men, Sundays and holidays, 26	9,360	
General repair gang, 45 men	67,500	
Yard gang, 12 men	16,200	
Machine shop force, 9 men	16,200	
Stock room and packing, 30 men	40,950	
Miscellaneous, 15 men	15,000	
Superintendent and office force, 6 men	12,460	
Engineering and chemical service	12,100	
Total service		$351,620

Supplies:		
Sacks, basis 1 month's output	$ 17,750	
Kiln lining material. . . .	10,000	
Fuel, 55,700 tons at $4 . .	222,800	
Gypsum.	10,000	
Repair parts, 3% of equipment	30,000	
Miscellaneous. . .	52,000	
Total supplies . . .		342,550
Administrative and general expenses, including salaries, sales expense, office expense, water supply, freight and express, yard maintenance. . . .		75,000
Machinery replacement and emergency		15,000
Fixed charges:		
Interest on bonds ($1,000,000). .		50,000
Insurance 1½% of machinery and buildings		12,990
Taxes, 1½% on $1,500,000 .		22,500
Depreciation:		
Mill machinery, 8%.	$ 17,726	
Power machinery, 5%	15,000	
Machine shop, 6%	2,100	
Buildings, 2%	6,740	41,566
Total operating expense		$ 911,226
Output, 2,500 × 300 days at 90% capacity, barrels .		675,000
Cost per barrel. .		$1.35

It is to be noted that the above estimate does not include dividends to stockholders or any surplus which a year of practically full-time operation should yield in order to make good on other years of poorer demand. Any such estimate is subject, also, to errors incident to varying wage scale, fuel costs, etc. Each dollar difference in cost of coal means a difference of $0.081 in cost of cement.

LEATHER TANNING

The leather manufacturing industry yields another important material. It is an industry neither synthetical nor analytical, strictly, although under the tanning process the hide does absorb some of the treating materials. In the main, the process serves to change the condition only of the raw hide, altering its properties to a considerable extent. The process materials in the present state of the industry are varied in kind, and the change in this respect has had a striking effect on the manner of conducting the business. Under older conditions, when hemlock bark was the

chief tannin bearing substance employed, it was cheaper to ship the hides to the locality furnishing the bark. Now it is easier to ship the tanning extract; but since hides are readily transported also, the origin of raw materials has a minor influence. Enterprises are located with reference to other important factors, therefore, largely those of established precedents or habit. It is a unique industry, in that the finished product is shipped as readily as the materials. In producing certain kinds of leather, however, especially sole leather, bark is still employed, so there is reason for that branch remaining concentrated in the Milwaukee-Chicago district as it does. Under these conditions it seems strange, at first, that many important shoe manufacturing towns—St. Louis, for instance—produce no shoe leather at all. The reasons have already been given, however—the shoe industry following market and leather being easily shipped.

There are numberless classes and grades of leather, so that in a consideration of process for the purpose of bringing out industrial elements in the organization and management of an enterprise some one class must be chosen. It may be noted that a sort of classification may be made on several different bases, each having a bearing on process. One such is to distinguish between "finished" and "unfinished" leathers. Another is on the point of a leather being whole in thickness, or split. Another is on the basis of leathers tanned with vegetable tannins, on the one hand, and with mineral base material, on the other. Chrome leather, which supplies upper leather for shoes almost entirely, is the best example of the last variety. Of the finished leathers there are three marked varieties; namely, sole leather, chrome leather, and a general class that may be called "oak" leather, used for a great variety of purposes, including belting, harness, saddles, and many kinds of leather miscellanies. This last variety will be taken as the basis of what follows, although in matters of process most of it would apply to sole leather.

The process in bare outline only, without consideration of alternative methods or newer practices adapted to newer tanning materials, consists of the following steps:

Soaking.—Mechanical treatment in water. Rotating drums or tumblers employed to hasten process. Chemical assistance sometimes provided, in form of one-tenth of 1% solution of caustic soda, or otherwise by weak acid solution, or simple salts. Purpose is cleansing and softening.

Depilation, or Dehairing.—Several methods employed. The most representative employs lime in the form known as milk of lime, with small amount of caustic soda or sulphide if the hides are difficult to treat. The liming process requires from 14 to 21 days. The three-pit system is commonly used, the hides remaining in each not less than 3 days. They are hauled (removed and piled for a few hours) each day in the first pit, and once for each of the others. Use of warm water hastens the process. The last pit contains fresh liquor. Harness leather is given longer treatment than sole leather. Light skins are given modified treatment. Swelling and plumping occurs here, as well as the separating of the hair cells. The mechanical part of dehairing is performed best by hand, but extensively by machines. See Bennett's "Manufacture of Leather" (Van Nostrand), and Rogers' "Industrial Chemistry" (Van Nostrand).

Deliming.—After the dehairing is completed the hides must be cleansed thoroughly from all traces of lime. "Puering" or "bating" are terms used. The hides are kept in pits of liquor for several days, with frequent hauling. The liquor is commonly a solution of bird or dog manure, but in recent years a chemical bating material has been used. The action is partly chemical and partly bacterial. The process involves considerable handling, so-called "rocking," calling for some power equipment; also overhead conveyors. This is an important step in the process. Pure soft water is called for. When process is completed, a thorough washing is given and the hides sent to the tanning room.

Tannage.—There is great variation in respect to both methods and materials. In the main, the hides are held "over sticks" in a weak liquor, to which fresh strong liquor is added every 2 or 3 days, for a period of perhaps 18 days, with frequent handling to secure uniformity. They are then packed in "lay-aways" —pits of tanning liquor with layers of ground bark between hides —for perhaps 100 days or more, with variations according to conditions and character of goods. This calls for extensive pit systems in order to maintain a continuous production. For example, 100 hides per day, in treatment requiring 140 days in full process, means 14,000 hides in the various pits, calling for well-ordered construction and heavy investment in stock. There are methods that are quicker, as by rotating drums, but for the heavy leather. the time process holds.

Finishing.—The remaining steps call for considerable mechanical work. The leather (no longer hide) is first soaked in water, "fleshed" or shaved, then dried, dipped in tallow or other oil for "stuffing," dried out in a series of high temperature rooms, worked out to soften in drums, stretched or "set out" on tables, worked by hand or by machines, or both, shaved for uniformity in thickness, colored by dyes or surface blackening, and finally trimmed to market sizes and sorted for the special grades and classes. Several machines and overhead monorail and trolley carriers constitute the mechanical equipment. The reference books noted above give information in more detail on all phases of the process.

For a more definite view of the industrial establishment an example based on actual operating conditions for a moderate plant in the pre-war period will be given. The leather business is one of great variations, so that Census averages are of lesser value. There are many processes employing a variety of tanning substances, for which the demands of the physical plant differ materially. The value of hides is another factor subject to pronounced changes from various influences, so it is impracticable to do more than give a single instance that will illustrate some of the important relationships, but which may not be taken as a financial guide on absolute values.

The plant is one producing "oak" leather for harness and saddlery use in the main. The value of product, actual sales value, is $500,000 per year.

The capital necessary to build and equip the plant, including the amount tied up in hides in process, is about $550,000. Assume $300,000 stock investment and $250,000 in bonds and loans. If handling the larger beef hides, the plant will turn out 90 to 100 per day, calling for the employment of 85 to 90 persons in all branches, including the offices. About 250 hp. will meet all demands for power and pumping about the plant, unless the water supply is especially difficult to secure. The water supply is of first significance, both in quality and quantity. For this plant the consumption will be not less than 250,000 gal. per day of soft, clear water. Treatment for softening and filtering is usually necessary. Electric motors should be used for general service of machinery, but the need for heat in various steps of the process requires steam equipment. Engines or

turbines with high pressure exhaust are likely to prove most adaptable.

The plant will require a building with a ground floor area of 25,000 sq. ft., about half of which must be of two-floor construction to provide drying and finishing rooms on the second floor. The process calls for hemlock and oak bark shed storage in a yard of not less than 3,000 cords capacity.

Operating expenses are about as follows:

Materials:		
Hides	$340,000	
Process materials	13,000	
Fuel	8,000	
Miscellaneous supplies	1,500	$362,500
Labor		62,000
Administration expense		10,000
Sales expense, including freight		15,000
Interest on loans, bonds, etc., 6% of $250,000		13,000
Insurance and taxes, 2½% on $300,000		7,500
Total expenditures		$470,000
Income from sales		500,000
Net income		$ 30,000
Dividend of 8% on stock (assumed)		24,000
Surplus		$ 6,000

PAPER AND WOOD PULP

The paper and wood pulp industry is one of the largest in this country, and presents many unique features. The processes call for heavy capital expenditures in the form of machinery equipment, so that the engineering activities associated with a large enterprise assume much greater proportions than is the case with many.

Mention has been made already of the fact that power and raw material demands have forced the large paper mills back into the woods to water power sites on the rivers. This means that early in the formative stage of a new undertaking, extended surveys and studies of power and transportation possibilities are necessary. These determine the location in the local sense, and usually figure largely in the determination of the general conditions. It has been seen that this is the greatest power user of

all the industries in proportion to created values. Power development, once the location is fixed, constitutes, therefore, the next step in general plant design. To accomplish this successfully, the processes must be understood, especially with reference to power demand. Wood pulp paper will be made the basis of the analysis.

First Step—Manufacture of Pulp.—There are two distinct processes—the mechanical or ground pulp process and the chemical process. The latter includes several types, such as the sulphite process and the soda process, both of which are subject to minor variation.

The mechanical process is purely what the name implies. The wood is cut into short lengths, not over 2 ft., cleared of knots and decayed portions, and barked. The sticks are then placed in containers where hydraulic pressure forces them against a rapidly revolving stone which grinds away the fiber in the presence of a stream of water which washes the ground mass away through strainers to a sump, from which pumps convey the heavy fluid to the tanks for treatment. It requires 45 hp. to grind 1 ton of pulp in 24 hr. of continuous operation. No effort is made here, or later, to separate the wood fiber from the starch and other intercellular substances, so that a bleaching treatment of the pulp is not possible. This makes necessary the use of only the light-colored varieties of wood, such as poplar and certain varieties of spruce containing little resinous matter. The grinding process produces a short fiber, so that paper made from this pulp alone is soft and of low strength. It is used mainly for newspaper stock, for which it is mixed with the longer fiber sulphite pulp, as noted later. If not used at once for this purpose, it is passed through the mixing tanks to the flow box and thence to the forming cylinders, as will be described later in the paper making process. From here it is carried in a thick sheet to dryers and rolled out in heavy sheets, that may be either folded flat or wound into rolls for transportation to the paper mill.

A moderate-sized mill producing 25,000 tons of pulp per year requires 3,600 hp. for the grinders alone. Additional power to run the saws, barking mill, conveyors, spare grinders, pulp pump, mixing paddles, forming cylinders, centrifugal pumps, and rolls amounts to about 6,000 hp. plus several hundred horsepower of boiler capacity for drying. This, it is to be observed, is to produce the unformed and bulky pulp only—not paper.

The excessive power demand for producing a relatively low-value pulp makes the process impracticable, except as cheap water power is available. If a good water supply under natural head is not available for washing the pulp from the grinder, the costs of pumping would have to be added.

The sulphite process is more complicated, but yields a much more valuable pulp. The chemical phases will be touched upon only incidentally, the aim in this discussion being merely to bring out the main features of plant layout. In all chemical processes the wood is prepared by chipping it into small, thin pieces the size of a silver quarter dollar, or slightly larger. The chipping machines correspond to the grinders of the mechanical process, with revolving cutters instead of the stone. Somewhat less power is required per machine and the capacity is greater. In straw and other similar fiber mills no preparation of this sort is necessary. The material then goes to large cylindrical cookers or digesters, which are steel sheels with lining material suitable to resist the cooking liquor according to the process employed. To this point the statements apply to any chemical process.

For sulphite pulp the liquor is prepared by burning sulphur in ovens or furnaces and passing the sulphurous acid gas through tanks of milk of lime, or through towers containing blocks of lime over which water is flowing. A typical liquor contains 2% of free sulphurous acid, 1% of combined acid, and 0.83% of lime. The amount of sulphur used varies from 250 to 400 lb. per ton of pulp, according to the character of the wood, about 2,500 gal. of liquor being employed. The equipment includes a carrier for charging the digester with the wood and pumps to handle the liquor.

By the "quick cook" method the pulp is digested in 8 to 9 hr. under a steam pressure of 80 to 100 lb., maintained by connection with boilers. The steam is turned directly into the digester. When strong liquor is used, the pulp produced is soft and easily bleached for white paper. Weaker liquor produces a strong, dark-colored paper used for bags and wrappers.

By the "slow cook" method 30 to 48 hr. are required. Heat is applied by steam at about 15 lb. pressure, circulated in lead pipe so that water of condensation will not mix with and weaken the liquor. An especially strong paper results, but the process is so slow that it is employed only for special grades of product.

The soda process is similar, as regards mechanical methods employed, to the "quick cook" acid sulphite process. The liquor is a caustic soda solution of a density of from 8 to 10°Bé., which calls for about 600 lb. of the chemical per cord of wood treated, yielding 1,200 to 1,600 lb. of air-dried pulp. The soda is purchased in the form of soda ash, which, in combination with milk of lime, forms the sodium hydroxide. Great care is necessary in the soda process to avoid injury to the fiber.

After digesting by any of these methods, the mass of pulp and liquor is blown out of the digester by steam into tanks, and washed thoroughly, the washing requiring as much as 40,000 gal. of water per ton of pulp. If it is to be transported to a paper mill, the pulp is strained, squeezed, and rolled into sheet form, as described before. Combined pulp and paper mills, that mix two or more grades of pulp, usually make only one kind and purchase the other. This means that large quantities of sulphite pulp are shipped to paper mills for mixing with mechanical pulp for newspaper stock.

The Manufacture of Paper.- The newspaper stock business is representative and constitutes a large fraction of the industry. Commonly, it is made from a mixture of 70 parts mechanical and 30 parts sulphite pulp. About eight parts of china clay for body and small amounts of glue or resin for sizing are added.

The first step is the bleaching of the pulp. This is done either by chloride of lime or by a solution of hypochloride of sodium or magnesia. The latter is prepared by electrolyzing sodium chloride, forming in solution the hypochloride. Four to five thousand kilowatt-hours are required per ton of chlorine treated. Forty to eighty pounds of chlorine, according to conditions in the digesting process, will bleach a ton of air-dried pulp.

After bleaching, the pulp mixture goes to the beater in thin liquid form, where it is mixed thoroughly, then to the flow box and the forming cylinder. This latter is a slowly revolving cylinder with perforated surface, which picks up the pulp and allows the water to flow through to the center. A centrifugal pump is used to keep the water level inside the cylinder several inches below that outside. The speed of the roll regulates the thickness of the sheet of pulp, which passes under a felt "squeeze" roll at the top. The felt picks up the sheet and carries it over a suction box where more water is removed, delivering it finally to press rolls, where the last mechanical act for expelling the water

is performed. After pressing, the pulp sheet is strong enough to leave the felt, and in this form is taken through more rolls on its way to the dryer. The dryer consists of a series of cast-iron rolls heated with steam of gradually increasing temperature, from which the sheet goes to the calender rolls, which are of very smooth chilled iron. It is now paper, with a fair surface.

The above steps are representative of what takes place, but the description is not complete for paper making on modern machines. The Fourdrinier machine is the leading type, for descriptions of which see Rogers' "Industrial Chemistry" and Cross and Bevan's "Paper Manufacturing."

The fine grades of paper are produced by refined processes, some of the finest from cotton or other long-fiber pulp mixtures by delicate hand operations. For present purposes we need go no further in description.

Power demands continue throughout the plant. It has been seen that steam is required for digesting and drying, so that a boiler plant is necessary, however plentiful the supply of power by water. In many plants steam engines are used to drive the paper machines, for which service they are fitted by reason of the close degree of speed regulation that can be attained in a properly designed engine. There is a large amount of wood refuse available for fuel, so that the amount of coal purchased is relatively small.

Much of the material moved in the plant is in liquid or semi-liquid form, calling for many special pumps. These may be steam or motor driven. Large floor space is required for operations, and considerable storage under cover for pulp and chemicals. A very large amount of outdoor storage is necessary for logs accumulated during the winter and spring seasons. This calls for tracks on which to move the timber both before and after cutting to length for grinder or chipper. Quite commonly water in flumes serves instead of tracks for this service—water power in a direct form.

The heavy service, and the corrosive action of chemicals in some measure call for extensive repair shop equipment. Some of this equipment must be for very accurate work on rolls and closely adjusted paper machinery.

Labor is variable in nature. A few highly skilled men are required in each division—especially at the cookers and paper machines. Several skilled millwrights and machinists are neces-

sary. Many unskilled workers are employed, and here the labor turnover is usually large. Much depends upon trained chemists and the superintending force.

The following financial analysis is representative of conditions under pre-war prices. Since the war, prices of paper have fluctuated considerably, so no attempt is made to adjust the figures to present conditions. The statement covers construction and operating costs for a combined pulp and newsprint paper mill producing mechanical pulp and purchasing sulphite pulp for paper mix. Capacity, 25,000 tons of paper per year. Location is at water power site on a stream that will float the major portion of the lumber from the timber lands to the plant. This means the manufacture of about 20,000 tons of ground wood pulp and the purchase of 8,500 tons of sulphite pulp and 2,500 tons of china clay and sizing material as the major raw materials. Total power requirements will be 9,500 hp., of which 7,500 hp. may be generated from water. With an effective head of 60 ft. on the turbines, allowing 70% over-all efficiency, this calls for 1,575 cu. ft. of water per second.

In the initial survey, it may be assumed, it has been found feasible to store the wood, in the form of long tree trunks which are floated to the plant on the river during the spring high-water season, in a semi-natural lake on the upper level, entered by a channel cut from the river. This provides log storage at a cost of $50,000 spent in cutting the canal from the river and damming an outlet ravine to impound the water. This construction forms a portion of the head works in the water power development.

FINANCIAL ANALYSIS

Income of company (manufacturing plant alone), 25,000 tons @ $80		$2,000,000
Investment, not including timber lands:		
Land at site, including power privilege	$ 20,000	
Power development, 7,500 hp. @ $90	675,000	
Log storage, noted above	50,000	
Steam power equipment, 2,000-hp. boiler capacity, 500-hp. engines	75,000	
Buildings, 108,600-sq. ft. floor @ $2	217,000	
Equipment	750,000	
Organization expense	100,000	
Engineering, 10%	190,000	
Loss on initial operation, experiments, etc.	200,000	
Stocks on hand and cash	350,000	2,627,000

Operating costs, materials:		
Pulp wood (basis of purchase from outside) 30,000 cords at $6	$180,000	
Sulphite pulp, 8,000 tons at $70	560,000	
China clay, 2,000 tons at $25	50,000	
Limestone, salt, and miscellaneous chemicals	10,000	
Fuel:		
8,000 tons coal at $6	48,000	
500 tons smith and foundry coke	6,000	
Lubricating oil and other power supplies, 9,500 hp. at $5	17,500	
Miscellaneous supplies	15,000	946,500
Labor:		
Salaried officials, 32 at $3,000	96,000	
Wage earners, 400 at $900	360,000	456,000
Maintenance and repairs:		
Buildings and permanent structures, 2%	$ 12,090	
Equipment, 5% of $1,162,500	58,125	70,215
(Water power development cost divided equally between permanent structures and equipment)		
Depreciation:		
Buildings and structures, 1½%	$ 9,060	
Equipment, 5%	58,125	67,185
Insurance: 1% on buildings, ½ of equipment, and stocks		11,480
Taxes: 1% on $1,750,000 assessed valuation		17,500
Interest: 5% on bonds (assumed $1,000,000)		50,000
Total expenditures and depreciation reserve		$1,618,880
Net income		381,120
Assumed dividend 10% on $1,627,000		162,700
Balance to surplus		$ 218,420

As in many industries, the handling of materials is an element of operation that is important. The pulp and paper mills deal with a substance that is being transformed from long logs to a thin liquid and back again to heavy rolls of paper. Limestone salt, clay, and coal must also be handled. Traveling cranes, track derricks, bucket elevators, belt conveyors, screw conveyors, pumps, motor trucks, and hand trucks all have their points of application. (For a description of several of these appliances see the magazine, *Industrial Management*, February and March numbers, 1919.)

From the standpoint of organization and development, the pulp paper business is one of the most complex. Its high-power

demand makes it imperative that establishments be on a large-unit basis, and even then operating margins are small under normal prices. The processes call for much technical service, both chemical and mechanical. Engineering occupies a large place, as already noted. A matter not yet mentioned, that makes the undertaking more complex, is that of operating timber lands for pulpwood. Most of the large companies have found it necessary to purchase large tracts of land and to start reforesting methods in order that the future supply of raw material for their plants may be assured.

The utilization of pulp, made from wood and from various other materials, is assuming considerable importance and is likely to increase greatly. The 1920 census gives data covering 40 establishments with a combined capital of $17,000,000 and a value of product of nearly $24,000,000. This is in addition to paper boxes and miscellaneous paper goods—separate industries with a combined capital of nearly $200,000,000 and over $300,000,000 value of product. These articles reflect the tendency to meet the growing needs of the population by utilizing resources that were unknown in the earlier stages of development. At the same time it indicates a possible menace to the forests, the preservation of which is becoming one of the important national problems.

SUGAR REFINING

Sugar refining is another large establishment industry with many complex and interesting processes calling for both engineering and chemical skill combined with good management. Margins run low in both cane and beet branches, so that economies are carefully studied.

From the engineering standpoint, designers must provide for a strictly up-to-date and efficient steam plant. Steam is employed for heating, the use of exhaust steam being feasible at several points. The sugar mill itself is largely electrified, so that electric power generation calls for careful attention. In the beet branch there are usually various additional elements to be considered relating to power. Here the sugar mill can operate for only a short portion of the year, 100 to 120 days, and auxiliary service must be considered. Beets are grown in rotation with alfalfa, so there are large quantities of the latter crop to be ground and handled. Much of the beet crop of the United States is grown

on irrigated land in semi-arid regions. This may give rise to a demand for power for pumping irrigating water, which is a service "off-season" as regards sugar mill operation. These combine to make an important element in the engineering work. In one 6,000-ton plant there are installed 91 electric motors, totaling 1,608 hp., this including motor driven boiler feed pumps and the machinery of the alfalfa feed mill.

Confining attention to beet sugar, the plant must be laid out with first reference to the process—which imposes certain characteristics. The materials move readily to different levels rather than horizontally, giving rise to a building with at least three floor levels above a basement storage for finished sugar. Actual floors are not built in continuously, however, since part of the equipment (evaporators and filters) extends conveniently through two floors. Open gallery construction is preferable at the second floor.

Outside storage for 20,000 tons or more of beets must be provided; also for considerable quantities of limestone. Kilns to burn lime, involving apparatus to make the CO_2 gas for use later in the carbonation steps, must be provided. The first step preliminary to the process itself includes washing the beets, elevating into the mill, usually to second floor level, weighing and then putting them through the slicers. From here on the process is of major interest to chemists, and the reader is referred to Rogers' "Industrial Chemistry." The following list of equipment items serves to outline the process (Steffen) and also to indicate the power distribution. It applies to a plant producing 6,000 tons of sugar in a season.

PROCESS AND POWER EQUIPMENT

	Motors	Horsepower
Beet shed, picker and conveyor	2	7 0
Beet wheel and refuse pulp pump	1	40 0
Beet washer.	1	10 0
Beet elevator	1	15.0
Knife files and trailings elevator	1	5 0
Beet slicer	1	40.0
Lime kiln, hoist, crusher, pulverizing mills and fans, blower at kiln, powered lime scroll, CO_2 fan and compressors, ventilator fan, elevator	14	242.0
Diffuser battery water pump	1	40.0
Raw juice and evaporator pump	1	30.0

PROCESS AND POWER EQUIPMENT (*Continued*)

	MOTORS	HORSEPOWER
Carbonation receiving tank	1	1.0
First and second carbonation pump	1	75.0
Auxiliary carbonation pump	1	30.0
Waste juice pump	1	3.0
First hot press, washer	1	5.0
Hot press scroll	1	7.5
Pump and heater, second carbonation	1	5.0
Heater, sulphur station, thin	1	10.0
Thick press and sulphur station	1	10 0
Juice to second sulphur station	1	7.5
Washer, second hot press	1	5.0
Mud pump and mixer	1	7 5
Evaporator condensed water pump	1	10 0
Centrifugals, white and brown	2	150.0
Centrifugal spray	6	3.0
Granulator	1	25.0
Granulator fan	1	10 0
Crystallizer	1	7 5
Sugar melter mixer	1	2 0
Wet sugar elevator	1	3 0
Dry sugar elevator	1	5.0
Bag sewing machine	1	2.0
Sacked sugar conveyor	1	7.5
Steffens house: air compressor, cold press pumps, agitator, waste water pump, rattler, etc	7	175.5
Pulp dryers, conveyor, feed mixer, grinder, etc	6	72.0
Water supply service with boosters in plant	8	410.0
Machine shop	8	33.0
Power plant	8	96 0
Miscellaneous	2	8.0

The actual power consumption is about 60% of the connected motor load, representing about 600 boiler hp. with modern generating equipment.

Cane sugar production differs in many respects from that of beet sugar. It is divided into two distinct steps, the first being the production of raw sugar and molasses from the cane, carried on near the cane plantations. It is seasonal like the beet industry, the crop being cared for after the harvest. The raw sugar commonly goes to separate refineries, which may thus operate continuously. The process is simpler than with beet sugar, and the mechanical appliances are less prominent in the opening stages. In other respects the foregoing list of equipment items is sufficiently indicative of the plant in respect to the physical features, and so will not be repeated.

The large cane refineries afford illustrations of the highest types of engineering work, directed toward fuel economy and the elimination of labor in handling materials. One of the latest plants, having a capacity of 10,000 bbl. per day (350 lb. per barrel) has installed 10,600 boiler hp. rated capacity, operating normally at 50 to 75% above rating. This is only 60% of the power indicated per barrel capacity in the beet sugar plant whose equipment is outlined above. The difference is due in part to process—handling of beets and slicing not being included and in part to the large size of the cane sugar establishment.

The refining branch is the only one susceptible to financial analysis, because of the seasonal character of the other. The following is fairly representative of a medium size of establishment, having a capacity of 5,000 bbl. of refined sugar per day of 24 hr. A barrel weighs 350 lb., so that the total annual output on the basis of 300 working days figures at 262,500 tons of sugar. The figure of 250,000 tons is used.

Significant relationships are:

Amount of raw sugar to yield 1 ton of refined	1.22 tons
Fuel required per ton of raw sugar	0.41 tons
Tons raw sugar handled per wage earner	2,358 tons
Value of by-products, 1.1% of value of refined sugar	
Value of products per wage earner	$32,600
Salaries to officials equals 21% of wages paid.	
Values for 1921:	
Refined sugar, per ton	$166.50
Raw, per ton	$117.20

INVESTMENT

Investment in plant	$ 9,250,000
Inventories, raw and refined stocks	3,500,000
Working capital	975,000
Total capital	$13,725,000
Division on income-earning basis:	
Borrowings on interest at 5.5%	3,000,000
Accounts not on interest	500,000
Fixed investment	10,225,000

Operating Account

Income:		
250,000 tons at $166.50	$41,625,000	
By-products, 1.1%...	457,875	$42,082,875
Expenditures:		
Materials:		
305,000 tons raw sugar × $117.20	$35,750,000	
Fuel, 125,050 tons coal at $5	625,250	
Lime, bone black, chemicals, etc	2,126,000	
Labor:		
Wages to 1,290 employees	1,287,000	
Salaries to officials	308,000	
Fixed charges, covering depreciation, maintenance, insurance, taxes, 9% of plant	832,500	
General expense, including sales, but exclusive of salaries	150,000	
Capital charges:		
Interest, 5.5% of $3,000,000	165,000	
Dividend, assumed 7% on $10,250,000	715,750	
Total of all expenditures, including dividends		$41,959,500
Surplus		$ 123,375

STARCH AND GLUCOSE

The starch and glucose, or, in common terms, the corn products industry is one calling for much the same sort of engineering work as sugar refining. Since corn keeps for indefinite periods under proper conditions, continuous operation is the rule, and high-grade equipment for power generation and application, with the best devices for handling of materials, is demanded for efficiency. The small potato starch factories are necessarily seasonal in operation and do not come within the class of enterprises contemplated in the following discussion. Plants using wheat are similar to the corn mills in many respects.

A plant consuming 1,000 bu. per day will be used as a type. It is small in comparison with a few modern establishment, but is still representative of good practice. It has standard elevator storage for 50,000 bu. of corn, in three 20-ft. diameter elevators. In addition to this there are, within the mill, several bins having storage capacity for several days run. This is the first element to provide for as the plant layout is being considered, and for it about 800 sq. ft. of floor space should be allowed. A

good arrangement is to place this on an upper level, in overhead bins feeding by gravity into conveyors that carry the corn on its way to the initial-process containers. Bucket elevators from the unloading chute hoist the corn to these bins, as coal is handled in large power plants.

It should be understood at the outset that the first steps in the process involve the use of much water, so that the equipment and floors are continually wet and the atmosphere heavily charged with moisture. Such a condition is unsuited to the handling of the product in its later stages. Therefore, two separate buildings are desirable, one being called the "wet starch" and the other the "dry starch" building. In the wet section, 60 by 85 ft., four floors are assumed. A third building is the feed house, the feed being a by-product of great importance, and a fourth the power plant.

The water supply is a factor of prime significance, both as to quantity and quality. The first (basement) floor of the wet building is used in large part for water treatment and storage. The water usually requires softening and must be free from sulphur. A half million gallons or more per day is required. This means that the natural water supply is a leading consideration in the selection of a location—a matter previously noted.

The chemical treatment need not be given in detail, as the following outline notes on equipment indicate the character of the process with all the accuracy necessary at this stage.

Washing.—Corn from the storage bins is carried by conveyor to plain tanks fitted with motor-driven agitators. Floor space 300 sq. ft.; fourth floor; 2-hp. motors.

Steeps.—Corn taken to tubs and soaked in solution of sulphurous acid; 10 to 15 tons; 3,000 sq. ft.; third floor; corn 3 or 4 days in steep; liquor heated by steam, in tank above, to 120° F. and circulated by gravity through the tubs.

Evaporators.—Steep liquor from tubs is here concentrated for use later in feed mill. One large pan on second floor; steam heated.

Degerminators.—Corn to "fuss mills" on second floor; two in operation; mill consists of container with two vertical planes revolving in opposite directions, bringing corn under moderate pressure to squeeze out the germs; 500 sq. ft.; 4 motors, 15 hp. each.

Germ Separators.—The pulpy mass is elevated from the fuss mills to fourth floor to the separators, which are half cylinder wood tubs, lying on their sides, 5 ft. diameter by 20 ft. long; water is circulated from the bottom, agitating the mass and carrying the germs to the top, whence they are sluiced off; the heavier starch-bearing body of the corn passes out below; six tubs; 1,400 sq. ft.; 1 motor, 25 hp. The two parts are then treated separately, as indicated by the parallel arrangement below.

STARCH BODY

Washing Reels: Rectangular wood tanks 4 by 8 ft. with two rotating reels and water sprayed over top; 9 tanks; 660 sq. ft.; water with starch to shakers below; coarse material moved out from bottom by screw conveyor; fourth floor or elevated on third; 2 motors, 10 hp. each.

Mill Tanks: Coarse material from reels received, mixed, and stored temporarily; 2 wood cylindrical tanks, 10 ft. in diameter; 500 sq. ft.

Buhrstone Mills: Grinders; coarse stones; vertical cylindrical form; 6 mills; 1,500 sq. ft.; second floor; 6 motors, 25 hp. each.

GERMS

Washing Reels: Same as for starch body; 3 tanks; third floor; 200 sq. ft.; 2 motors, 5 hp. each; water with starch washed off goes to shakers.

Dryers: Centrifugal expeller and then cylindrical flue type dryer using hot air; 750 sq. ft.; 1 motor, 20 hp.; 1 motor, 10 hp.; third or second floor.

Germ Bin: Dried germ storage; 100 sq. ft.; second floor of feed house.

Oil Presses: Four double screw presses; 300 sq. ft.; second floor feed house; 1 motor, 25 hp.

Oil Refinery: Separate building, producing oil for market.

Remaining mass from presses forms germ meal, a valuable cattle feed, sold as pressed cake.

(End of germ treatment)

Shakers.– The semi-liquid mass from the buhrstone mills is pumped to the third or fourth floor and distributed over 15 shakers, which are tables about 4 by 10 ft. set on an incline; built in the form of troughs 10 in. wide, screen bottom; 1,200 sq. ft.; 2 motors on line shafts, 15 hp. each. This is repeated on "silk" bottom shakers on second floor, which are bolting cloth screens through which the starch and most of the gluten are washed, the bran residue trailing off the lower end of the shaker. It is here that the washings from the reels join the main current; 600 sq. ft.; 1 motor, 15 hp. Another separation takes place here, as indicated below.

STARCH AND GLUTEN LIQUOR

Troughs: Also called "*Runs*" or "*Tables.*" Liquor from shakers, after agitation in tanks and adjusting to density of 4 to 6° Bé., runs slowly into troughs having very slight incline, 80 ft. long, 20 in. wide, 10 in. deep, arranged in three decks, 11 on each deck. As the liquor moves slowly down the troughs the starch settles to the bottom while the gluten remains in suspension and flows off at the lower end, whence it is taken to the coarse residue mixing tank. This equipment is in the range of second and third floors of the dry starch building, and with runways occupies 38,000 sq. ft. (In large plants the troughs are often built up to 120 ft. long.) The starch is shoveled out of the troughs, and goes to one of the two following receptacles for treatment, according to character of marketable product.

COARSE RESIDUE

Mixing Tank: Bran from shakers, gluten liquor from the troughs, and steep liquor from evaporators mixed; 200 sq. ft.; on second floor of feed house: 1 motor, 5 hp.

Filter Press: Bag filters; 4 horizontal presses; 1,200 sq. ft.; first floor feed house; hydraulic pressure by steam pumps.

Dryers: Ten cylinders, 6 ft. in diameter, 18 ft. long; 2,000 sq. ft., first floor feed house; pipe heater and fan; 1 motor, 25 hp.

Mills: Two ordinary feed grinders 250 sq. ft.; first floor feed house.

Product—gluten meal.

A. When it is marketed as starch, it goes to the *vacuum dryers,* which are horizontal cylinders, 8 ft. in diameter by 25 ft. long, equipped with vacuum pumps and steam heated; 9 dryers are used; 4,000 sq. ft.; first floor of dry starch building; 8 motors, rotating dryers, 15 hp. each; 8 vacuum pump motors, 17.5 hp. each; steam for heating. Product—pearl starch. As alternative, a portion (amount according to demand) is thinned again with dilute acid, boiled in vats, and precipitated as high-grade starch. Product—thin boiling starch.

Storage and Shipping.—The pearl starch is bolted and graded, and packed for market; 8,000 to 10,000 sq. ft. required, usually in a separate building; 2 motors (conveyor and bolter), 15 and 20 hp.

B. When the process is extended to produce glucose it is treated as follows:

Starch is converted to glucose by the hydrolyzing action of dilute acids, in which dextrin changes to dextrose. Commercial glucose, used extensively in food preparations, is produced when the action has proceeded to a point such that about 25% of the substance remains in the form of dextrin. (For a full

discussion of this, see Rogers' "Industrial Chemistry," pp. 772–778.)

Glucose production involves additional building space for the conversion of the starch; filtering the glucose in two steps, in bag filters and bone-char filters, as in refining of sugar; and concentrating in vacuum pan to a thick syrup. The converter, vertical in form, calls for steam at 50 lb. pressure. The syrup is handled several times with pumps, calling for about 200 motor hp. The vacuum pan concentrator calls for steam for heating and a vacuum pump with 25-hp. motor. Storage and handling equipment for the barreled syrup corresponds to similar provisions for starch. Building space of about 8,000 sq. ft. additional floor area is required.

The above schedule includes 48 motors of 915 hp. total, but does not include power for pumping water, grain elevator service, or for miscellaneous service in the plant. The plant has an actual installed generating capacity of 2,000 kva., 25% of this being in reserve units.

FUR-FELT HATS

Fur-felt hat manufacturing, men's styles, is a typical manipulative process, leaving out of account all dyeing or coloring of material. Plant design is a matter of providing space, equipment, and power for the several process steps, where the material is adaptable to movement without fixed limitation set by quality characteristics, except that in one series of operations water is used. In the initial series of operations, moisture is prohibited, because it would make it impossible to handle the fur. The dominating principle is to establish the routing of the goods in accordance with economy in operation.

The process may be considered under the following four heads, corresponding in general to as many subdivisions of the plant, which may be separate sections, rooms, or buildings, according to the size of the enterprise. The space and power figures correspond to a plant turning out 250 dozen soft hats per day. There will be used annually about 120 tons of rabbit fur and 20 tons of other materials, which include shellac for sizing, leather, cloth banding, alcohol, and dyes. Large quantities of hot water are used.

Preliminary Steps.—Storage of skins; cutting fur from skins; mixing; blowing; carding. These must be performed in a dry

atmosphere. The blowing is to remove hair from the fur. Carding rolls, called "devils," disentangle matted fur by separating the fibers. High-speed blowers are used, necessitating good machinery foundations. About 6,000 sq. ft. of floor space are required, half being for the blowing and carding; 60 hp. required.

Forming Series.—a. Forming. The fur is weighed into a cylinder and drawn by suction against the outer surface of a perforated copper cone that is rotated to insure uniform thickness of the layer. A wet cloth is wrapped around it and it is then dipped in hot water, followed by working or kneading with repeated dipping to harden the body. There are 24 machines, each requiring 20 hp. for the exhaust fan and rotating of cone. Floor space, 2,400 sq. ft.

b. Sizing. Continuation of hardening process, shrinking and molding to size on forms, with alternate wetting and drying; numerous rolling machines call for about 100 hp.; 1,600 sq. ft.

c. Stiffening. Special machines for rolling to form; shellac used on brims; 10 machines, 5 hp. each. Dyeing is done in conjunction with this step. Space required, 1,100 sq. ft., not including drying room.

d. Stretching and Blocking. Numerous special machines; 20 hp.; 600 sq. ft.

e. Centrifugal Drying. 200 sq. ft. 30 hp.

f. Pouncing, crown and brim separately; special machines combing up the nap; 400 sq. ft.; 25 hp.

g. Drying room, used repeatedly in above processes; 1,000 sq. ft. All except (*f*) are essentially wet processes and should be in building separate from finishing stages.

Finishing.—Mostly hand processes of ironing, added pouncing of brims, rounding, curling, flanging, binding, trimming, sewing leather bands, final finishing. Small machines used for ironing, cutting, and sewing; 6,000 sq. ft.; 50 hp.

Packing and Shipping.—900 sq. ft. General transportation, elevators, etc., 100 hp. Total, 923 hp.; 20,200 sq. ft. of floor space.

(For illustration of combined soft and stiff hat plant with routing lines, see Day's "Industrial Plants," p. 124.)

WOOLEN GOODS

The woolen branches of the general textile industry must be considered in three parts. The production of yarn is the first,

and includes the initial preparation of the wool, through the spinning process. Many plants are devoted exclusively to this. The second is the weaving of wool fabrics, generally carried on in conjunction with the first part. The complete plant, where the raw wool is prepared, carded, spun, and woven into cloth, is what is meant, usually, when the term "woolen mill" is used. In interpreting general statistics on the woolen industry, however, it is necessary to take into account the fact that many of the mills which are included carry the process only to the yarn stage. The third part is the producing of knitted goods. Here, again, there is a complication in classification, since the custom is to unite wool, cotton, silk and other kinds of goods in typical knit-goods plants. In the last group it is the process of knitting, similar in its utilization of the several materials, that dictates the scope of individual establishments, while in the first two it is the character of the raw material which determines the major steps in the process.

Because of this division of the industry, it is impracticable to use Census reports as a basis for estimating the cost of operation for any one of the types of plants, although figures for knit-goods are reasonably reliable if one assumes a plant devoted entirely to wool products. Direct methods are necessary, for which a tolerable degree of familiarity with the details is required.

In the United States wool carding and spinning developed early in the vicinity of Philadelphia, because of the large German population which was active in the knit-goods business. That initial start accounts largely for the continued prominence of that district in this class of production. In a similar manner the activity of the cotton fabric industry in New England drew the woolen fabric production into that region. These quite natural tendencies are responsible for the segregation which has persisted in the development of all three of the branches of the general woolen industry. Another influence which has held it in the Atlantic states is the importance of a humid atmosphere as an aid in the manipulation of the wool fibers in the process of spinning. This advantage is minimized, however, by the more recent practices of controlling the air condition by artificial means, even in the regions of high natural humidity.

In the analysis, a complete mill, producing a medium-grade cloth, will be used. The data may be adapted to a mill which markets the yarn by simply stopping the process at an intermediate

point, although such a mill should be of larger relative capacity to insure economical operation. Figures are based on carding 500,000 lb. of wool annually (a small mill), which calls for what is termed a "six-set" mill, the term referring to the equipment in the carding room, as will be seen later.

It is impossible to assign a value to wool that may be expected to hold for an extended period. In 1909 the average price on both foreign and domestic clips, as purchased by the manufacturers of Massachusetts, was 28.1 cts. per pound. In 1914, it was 23.5 cts. In 1919, it was 66 cts. Current quotations on wool in the mountain states of the West at the present time (February, 1923) range from 50 to 56 cts. What the coming years will bring cannot be foretold, but the convenient price of 50 cts. will be used in the illustrative calculations to follow. Similarly, the value of woolen goods at the mill, both as cloth and as yarn, will vary through ranges hard to estimate. This variation is due, not alone to cost of the raw material but also to changes in the wage scale and to changes in the relative amounts of all-wool, wool-and-cotton, cotton-warp-wool-filling, and variable grades of "shoddy" fillings in the total of fabrics produced. The figures for the Massachusetts mills were, for "all-wool" goods, $1.60 per square yard in 1919, on an average weight of 0.583 lb. per yard, and $0.629 in 1914. For the total of woven goods, all varieties, it was $1.19 in 1919, on an average weight of 0.529 lb., and $0.322 in 1914. For the illustrative calculation, "all-wool" goods will be assumed, in weight 10% lower than the Massachusetts average, and a general price 20% below the 1919 level. This gives a value per square yard of 80% of $1.60, further reduced by 5% to allow for the reduced weight, or $1.216.

Wool as purchased will yield about 62% of scoured wool, ready for carding. This means that 805,000 lb. must be purchased to give 500,000 lb. for use. In addition, there will be purchased recovered wool fiber "tops" and other short-fiber wool wastes, to mix with the filling, 10% of the wool in amount, or 80,500 lb., at 36 cts. per pound. The weight of finished goods, allowing a small percentage of loss, will then be taken at 550,000 lb., or 1,047,000 sq. yd. If the process be stopped for the production of a high-grade, long-fiber yarn for the knit-goods industry, the weight produced will be about 475,000 lb., valued at, say, $1.68 per pound.

From these general data we may proceed, with such degree of accuracy as is necessary at this stage in the development, to make a statement of investment and operating expenditures.

Investment:		
Land and buildings	$200,000	
Operating equipment	400,000	
Power equipment, 750 hp. × $140	105,000	
Working capital	145,000	
Total		$ 850,000
Operating account:		
Materials:		
Wool, 805,000 lb @ 50 cts.	$402,500	
Wastes, etc., 80,500 lb. at 36	28,980	
Chemicals and dyes	25,400	
Fuel (6 lb. coal per horsepower-hour)	31,250	
Miscellaneous	45,840	
Total		533,970
Service:		
Wages, 274 workers at $848	$232,732	
Salaries, officials and clerical	45,850	
Total		278,582
Fixed charges:		
Maintenance and repairs:		
Buildings, 2%	$ 1,900	
Equipment, including power, 4%	20,200	
Depreciation:		
Buildings, 2%	1,900	
Equipment 5%	25,250	
Insurance, 1% on $750,000	7,500	
Taxes, 1½% on $600,000	9,000	
Interest, 5.5% on $350,000	19,250	
Total of fixed charges		85,000
General expense:		
Replacements and betterments	$ 50,000	
Spoiled material, 5%	25,950	
Sales expense, 10% of sales	127,300	
General office expense	25,000	
Miscellaneous	15,000	
Total general expense		243,250
Dividend, 10% on $500,000		50,000
Total of operating cost		$1,140,802
Income from sales, 1,047,000 yd. at $1.216		1,273,152
Surplus		$ 132,350

Process steps to be given consideration as the functional design of the plant proceeds include the following, wherein approximate amounts of floor space and power are indicated for the more important departments. The flow of material is in the order of the processes as listed. The building would have, normally, two complete floors for the active operations, with a basement for storage of raw materials. A fourth floor above may well be provided for the final finishing processes and for storage of stocks ready for market. The demands of the carding machinery establish an economical width of building at about 50 ft., inside in the clear. Heating and steaming requirements make necessary a boiler plant, and it is assumed that electric power will be generated by means of engines of medium economy, the exhaust steam from which can be utilized most of the time. The power plant will be a separate building. Electric motors will be used throughout the plant, driving machines individually or in groups, as may be best arranged in the several rooms.

Storage of wool calls for 2,500 or 3,000 sq. ft. of space, provided with means for humidity control of the air. Under a normal condition, wool contains about 14% of its weight of moisture. If it falls below 10%, difficulty is encountered in handling it. Dry wool suffers loss in carding operations, and the tendency to electrify makes it hard to handle. For the storage room, the air should have a relative humidity of 60 to 70%. As already noted, basement space is adapted to storage, both of wool and of chemicals and other materials to be employed.

Sorting of the wool is a process of great importance. It is to be assumed that proper care has been exercised in purchasing to secure a proper length of staple. The term "staple" signifies the length of fiber. Long-stapled wool is used for worsted yard and fabric, especially the coarser grades. A medium staple is used for a finer grade of worsted dress goods and suitings, and even short staples may be used for fine worsted by a process of combing perfected by the French. In general, the short-stapled wool is used for plain woolen fabrics, although some of the longer fibers are used. The presence of the longer fiber in the main stock permits of the use of "noils," which are recovered wastes caused by breakage of the long fibers during the worsted combing processes, and of "shoddy," which is wool recovered from soft flannels and knit-goods. It has been decided that these wastes will be used to the amount of 10%. The sorting

consists in dividing the fleeces of wool into the parts corresponding to the portions of the body of the sheep—shoulders and sides, loin and back, legs, neck, etc. The wool from these parts differs materially as to length of staple and as to fineness. To do this work well, requires skill, and also a definite program for the run of stock through the mill in producing the various grades of yarn or cloth. It calls for a well-lighted room of 500 or 600 sq. ft. of floor space.

Scouring, bur-picking, and carbonizing are steps in the process of cleaning and freeing the wool from all forms of foreign matter. It is necessary that it be done thoroughly, since any particles of such matter remaining with the fiber make lumps which are very objectionable in both yarn and cloth. The methods and equipment used are extensive and complicated in character, requiring a space of at least 3,000 sq. ft.

The first step is the dusting of the wool, which, as the name implies, removes such dirt as can be shaken out dry. A second object in this process is to open up the more or less matted fleece, so that it will go to the scouring machine in an open, or "lofty," condition, favorable to the penetration of the liquor to every part. The duster is a simple box, of various shapes, with a revolving shaker and a suction fan to carry away the dust.

Scouring proper consists in washing the wool in liquors prepared to remove the grease and other impurities. There occurs what is called "yolk," consisting of true wool grease and "suint," the dried perspiration of the sheep. Aside from the mechanical difficulties which these substances produce, they also prevent uniform bleaching and dying. The agents most commonly used in the washing liquor are carbonate of soda (soda ash), soda and potash soaps, and ammonia. The formation of caustic soda or caustic potash must be carefully avoided. The potash soaps are preferable to soda soaps, tending less toward hardening the fiber. Various forms of tubs and washers with oscillating "rakes" to move the wool through the liquor to the carrier and squeeze rolls are used, but space will not be taken to describe them. On leaving the washers, the wool goes to dryers, where, in air of gradually increasing temperatures, the water is removed slowly, so as not to leave the fiber stiff and hard.

The next major step is bur-picking, during which burs and other objects which tend to cling to the wool are removed by a machine, in which the active agent is a revolving cylinder with

curved teeth which separate out the foreign matter. While not all of the fine pieces can be removed in this way, the larger ones are, and the vegetable matter remaining is reduced to such fine form that it is disposed of in the next process. Many types of machines have been devised for this work, descriptions of which may be found in books dealing in detail with the subject.

The last step in the cleansing process is that of carbonizing the vegetable matter remaining in the wool, already reduced to fine form. This is done by immersing in a sulphuric acid solution, usually of 4 to 4½° Bé. gravity. The strength may be varied according to the condition of the wool, that mentioned being as strong as is ever used except in very abnormal cases. Twenty to forty minutes in the bath is sufficient time to accomplish the result desired, which is to saturate the vegetable matter so that, when dried, it will crumble to powder and be easily shaken out. A dry process is sometimes used, wherein the wool is exposed to the fumes of hydrochloric acid for 2 or 3 hours. Still another process makes use of aluminum chloride, in a 6 to 8° Bé. solution. It has several advantages over the sulphuric acid process, chiefly in its being less likely to injure the fiber, and also in being less offensive to the workers. It is also free from the danger of spotting the wool with iron rust, since it does not corrode iron with which it may come in contact. After rinsing and a final drying, followed by a thorough dusting, the wool is ready to move on its way through the plant. It is now pure and clean, and, if the work has been well done, in open, "lofty" form, with the fibers free from each other, ready for the carding or combing process to follow.

Mixing of the various grades or colors that are to be worked into the product is the next step. This is purely a mechanical matter of building up successive layers of the several ingredients, in proportions set for the grade of yarn to be spun, but it must be done skilfully in order that uniformity may be secured. When a pile of the mixture has been built up, it is taken to a machine called a "mixing picker." The stock must be fed to the machine in such a manner as to bring the full depth, made up by the layers, to the action of the revolving teeth. The teeth pick off the edges of all the layers in uniform lots, and send the wool on through the machine.

Oiling the wool is the final preliminary to carding. In the repeated treatments in acid and basic solutions, washing in water

not always soft, and drying, the fiber is almost sure to become hard and slightly brittle. If left in this condition, the severe action of the card would be likely to break the fibers and the wool would not work smoothly through the forming and twisting processes. Electrical action would also be troublesome. To avoid all this, the wool is given a light application of oil, by a sprinkling system in connection with the picker. The best results are obtained with olive oil, but, on account of the expense, lard oil is used more generally. Oleine is another lubricant used quite extensively. Four to five quarts of lard oil per 100 lb. of wool give satisfactory results.

The floor space required for the mixing and oiling is not large, perhaps 800 to 1,000 sq. ft.

Carding is, in some respects, the most significant operation. As before noted, it is the determining process in mill capacity. The aim is to arrange the fibers into a continuous ribbon, called "roving." For woolens, the fibers are left crisscrossed in all directions. Enough of the longer staples must be used to give strength, and these will be found to extend lengthwise in general position. The shorter stock fills in among them. For worsteds, the process is quite different, and is called "combing," the aim being to arrange the fibers of the longer stock in parallel positions, so that the subsequent spinning gives a firm yarn.

A set of cards consists of three machines, set in tandem, called the "first breaker," "second breaker," and "finisher," respectively. When the roving comes from the finisher it goes through a "condenser," being there changed from a flat ribbon to a round soft cord, and thence to the balling machine, where it is made ready for transfer to the spinning room.

Cards vary in width of the main roll from 36 to 60 in., 48 in. being a standard size. This is the clear width through which the wool passes. The diameter of the roll is about the same as the width, and it is driven at a rate to give a surface speed of 1,000 to 1,200 ft. per minute. The length of a complete set is from 42 to 44 ft., and over-all width 7 to 8 ft. A six-set mill will, therefore, require a room 50 by 60 to 70 ft., the cards being set crosswise. Condensers and balling machines will increase the length by a few feet. The weight of a set is from 15,000 to 20,000 lb. The total power used in the card room will be nearly 90 hp. Two well-known makes of cards are the Smith and the Forbush. The Torrance balling machine is a much used make.

Spinning involves two major operations. The roving from the cards, containing some surplus material, must be drawn out so as to leave the exact amount for the size of yarn desired. This must be done before it has been given more than a very small amount of twist, so that the fibers will move easily on each other. A slight twist helps to give a uniform degree of extension, and hence smooth yarn. The second step is the true spinning process, where the twist is given to convert the material into yarn. In this final condition the serrated surfaces of the fibers cause the proper amount of resistance to prevent unwinding. Finally, the yarn is wound on bobbins and given the final preparation for weaving.

The machine on which these successive actions are performed is called a "mule." The differences in the processes of preparing wool and cotton are most marked at this stage, the handling of cotton being much more complex. The mule used in spinning wool carries the spindles on a traveling carriage, which moves back and forth, first drawing out the roving, twisting it, and then winding up the yarn on the return. No attempt is made here to describe the mechanism, full details being given in the references mentioned.

The capacity of a mule is designated by the number of spindles. Standard sizes range from 120 to 400 spindles. The mill being considered will require approximately 4,000 spindles, so the need will be met by using 10 of the largest size, or, perhaps better, fourteen 300-spindle mules, which would give a small margin of capacity. The latter size requires about 4 hp., making the power demand in the room about 60 hp. The spinning room is nearly as large as the card room, each mule requiring at least 120 sq. ft. of floor space.

Several additional machines are required for preparing the woolen warp for the weaving process. This involves spooling, dressing, beaming, and drawing in and reeding. The machines are known by the first three of these names, the others being largely hand processes.

Weaving calls for another special form of machinery, and will call for the largest room in the mill. The Crompton and Knowles loom is a standard make, and no description will be given. There will be required 64 standard looms, each of a capacity of 1,000 lin. yd. of 55-in. cloth per month. The space required is about 45 sq. ft. per loom, to which must be added a considerable area

for passages. A room 50 by 80 ft. will be needed. The power is $3\frac{1}{2}$ hp. per loom, or 224 hp.

Finishing of the cloth after it comes from the looms is the final step. This consists of the following:

1. Inspection and minor repairing of broken threads.
2. Fulling with water and alkali soaps, and shrinking.
3. Rolling in machine with regulating device to bring the cloth to uniform width.
4. Drying.
5. Shearing nap to standard length.
6. Rolling, measuring, etc.

These processes require a fair-sized room, perhaps 50 ft. square, and a few small motors.

Standard reference books for a more complete study of the entire woolen industry are: Rogers' "Industrial Chemistry" (Van Nostrand) "International Library of Technology" (International Textbook Company, Scranton, Pa.).

COTTON GOODS

Cotton goods manufactures constitute one of the standard industries of the country. It was the earliest in point of time to utilize mechanical power in organized factories, and around it has been waged the war between capitalized power and human workers for a century and a half. It has been characterized by child labor from the beginning. The evolution of the industry outlines a serial story of human relations in industry that is without parallel, and probably without end. The present child labor movement in the United States holds this activity as its major objective. While close margins and the character of the work called for at several stages in the process have always constituted an incentive to the hiring of the cheapest labor, which is child labor, it is undoubtedly true that we have here an illustration of the binding power of habit and tradition in industry. Generations of mill owners, frequently in actual family succession, have held to an indefensible doctrine based on the mythical happy family that works, grandfather to six-year-old infant, in the mill, thereby gaining a considerable income in total. Of course the limits have been clipped, but tradition remains. The fallacy becomes apparent through the reflex

effect on the price of cotton goods, which, set at a low figure, made possible in the age of competition by this type of labor, created a tradition in the purchasing public just as hard to eradicate, and persisting to trouble operators in these later years when they may honestly wish to change labor conditions.

These comments, seemingly out of order in this chapter, are not without point for the man who is determining the major characteristics of design. A plant for such an industry is influenced by established practice—not that cramped quarters will be allowed because old plants had cramped quarters—but, when labor is cheap, plants are not equipped to save labor in the same degree as might otherwise be done. With much unintelligent labor there must be minute subdivision of tasks and a force of overseers in large proportion. Care must be taken to safeguard the workers from injury. There is a sharply defined unit basis in the steps and substeps of the process, which influences arrangement of space. In spite of a numerous and relatively low-grade working force, it is a highly complex and technical industry, calling for high qualities of skill in many positions. It is a high-power industry, calling thus for the most economical types of generating and transmission equipment when water power is not available.

The detailed outline is omitted. Many of the steps correspond to the woolen-mill processes, and, for these, the figures for wool would apply. But there are important differences. The cotton fiber is much shorter than wool and demands more careful handling. There is less scouring, because cotton is clean, organically. The spinning process is much more extended with successive drawing and twisting machines, or "frames," as they are called, to bring the thread to fineness. The dyeing is a larger factor.

(For machinery descriptions see "International Library of Technology.")

CHAPTER V

DESIGN OF THE PLANT

The distinguishing characteristic of modern industry is the substitution of systematic methods for the trial-and-error methods of earlier days. Growth has been from within, outward, in the main—or at least it was so until comparatively recent years. It was not until demonstrations were made, showing the extent to which production could be increased and unit costs lessened by the application of scientific methods to the problems of internal administration, that it was realized that the layout of equipment and the facilities for handling tools and material played a distinct part in production. Not until then was the fact established, likewise, that the effectiveness of human effort is influenced by environment and systematic routine, in a degree such as to make profitable the most careful study of conditions under which work is being performed.

At the same time that the point of view in respect to these matters has been changing, there has been going on a transition in other lines. Industrial activity has taken on different aspects. Establishments have increased steadily in size, thereby making changes in the economics of production. It has come to pass that the investor and managing owner find it necessary to do business on a scale commensurate with that on which others are operating if they can hope to succeed. They must know what investments are warranted by the extent of business available to them, and what methods are being found suited to their projects. It may be said that in manufacturing we have approached a point of diminishing returns, so that margins on units of product must be accepted on a level such that economies unrealized in the past are necessary to insure attractive dividends. It is not economy of the specious sort, but a broad-gage policy of making proper investments in ways that are sound.

This is but one way of saying that it is the industry that is designed. The "plant" is more than buildings and process equipment. To produce these details is a step that has been

taken by engineers most successfully—trained specialists who have perfected machines and construction methods to a marvelous degree of excellence. The industry of the present day extends even beyond that scope. It is the entire complex organism that takes the raw material and delivers the finished article to the consumer.

The editors of the Annals of the American Academy of Political and Social Science, in the foreword of its issue for September, 1919, devoted to "Modern Manufacturing," give a description of a standard industrial plant in the following words:

> Its buildings should be designed for economy of operation, surrounded by ample, well-kept grounds, located in an open section of a community of moderate size, having both good government and good schools, adequate transportation facilities, convenient supplies of raw material, and reasonable accessibility to markets.
>
> The main object of the management should be to secure the greatest possible production compatible with the highest well-being of the workers. The means to this end will be modern equipment and scientific management, involving an intensive study of every process, the selection and training of the workers and such organization of the workers as will insure maintenance of standard practice. Both a low labor turnover and the assurance of continuous employment are essential.
>
> The selling policy should provide for full and fair description of goods with prices based on cost plus the smallest margin consistent with continued prosperity—costs to be determined by a system in which approximate allocations of overhead are reduced to a minimum. Sales in an unnatural market and of useless articles are to be discouraged.
>
> The property interests must assume responsibility for providing adequate capital, to be represented by bonds and cumulative preferred stock having proper relations to fair value and bearing reasonable interest rates, and should accept the theory that unproductive capital is not entitled to a return any more than idle labor is entitled to a wage . .

This conception of industry is on a high ethical plane. In an ever increasing degree successful producers are rising to it, however, and it is not too much to expect that the spirit therein indicated will become reasonably manifest among the enterprises which will typify the industry of tomorrow. This will be true because it is sound business policy. It is a sane basis on which the designer of an industry may establish his work.

The preceding chapters have been prepared as an outline for a designer of industry. One who is to perform this function must know the general principles on which manufacturing is based.

He must have a fair knowledge of the history of industrial development. He must know his market and the methods of estimating its absorbing power. He must appreciate the importance and influence of transportation, and the reflex effects of many industries related to his own. He must consider well the problems of location in their bearing on the great factor of distribution. He must have intimate knowledge of manufacturing processes and of equipment. He must be able to make reliable analyses of an industry and estimates of investments and operating expenses. Otherwise, he is an unsafe adviser to clients whose invested funds are entrusted to an enterprise for the success of which he is to become in large part responsible. To devise and plan producing plants that will meet the tests of operation, conforming to all these demands and conditions, is creative industrial engineering.

The stage has now been reached where concrete expression is to be given to the ideas which have been developing gradually. The plant is to be given form; equipment is to be selected; operating methods are to be foreseen and provided for. In doing this, the following phases of the work are to be undertaken:

1. Determine the equipment needs of the enterprise and the actual floor space required. This calls for an exact, detailed study of the process and the listing of all items of equipment that will be required. It includes not alone the main process machines, but as well the auxiliary small tool equipment, power apparatus, appliances for handling materials, tool making outfit, special appliances for storing small tools and stock, laboratory and other apparatus for research and inspection service, designing and drafting office equipment, and all other species of plant equipment demanded for effective operation. Exact specification of types, sizes, capacity, and, sometimes, of make must be prepared. From such a list, when fully adjusted to the enterprise, orders for equipment may be prepared and layout plans drawn.

The determination of floor space calls for fully developed routing plans. This means that studies must be made of the flow of material through the plant, piece by piece. The division into rooms depends partly on process demands, and partly on conditions contributing to good administrative control.

2. Formulate an adequate administrative plan. This has bearing upon subdivision of the plant into the rooms noted in the preceding section. A central planning department in the

organization also has an influence on space design and the layout of equipment, the tool room, etc. The plan to be followed in job analysis, task setting, instruction card writing, and material control calls for consideration. While these statements are made in terms referring to machine manufacturing processes, there are counterparts in other types of plants, although in many cases established methods are so closely determined by process conditions that there is small chance for variation. Such conditions must be observed.

3. Select the local site. Location of the plant in the local sense can be settled wisely only after full consideration of many factors. The city planning system may indicate the district that is open for enterprises of the sort in question, but even then there is some latitude. Questions at issue will include accessibility to railway lines, local traffic facilities, residence districts for workers, water supply, sewage lines, convenience in disposal of any especially obnoxious wastes, and land values.

4. Auxiliary service demands. Several matters call for consideration before the final decisions can be made as to the amount of land required and the grouping of buildings. Among these are:

a. General offices—whether a separate building at the plant, rooms in the plant, or in the business district of the town.

b. Hospital facilities for first-aid treatment of injuries.

c. Rooms for the comfort and welfare of employees, such as lunch rooms, meeting rooms for volunteer organizations and activities, educational facilities, and other interests, according to the policy of the administration.

d. Parking space for automobiles and bicycles.

e. Outdoor recreation space, athletic grounds, etc.

5. Design the buildings. While the final stages of building design may be placed in the charge of an architect, there are many details which the designing industrial engineer must settle. The preliminary plans, on which cost estimates may be based, must be made to determine approximate investment that will be demanded by the project. The first tentative plan is bound to come up for a serious study of the possibilities for saving in various ways, even to the extent of modifying operating methods or the volume of business. If it is a machine building plant,

for example, it may prove desirable to buy castings rather than invest in a foundry. In many respects changes may become necessary. All such contingencies must be gone over carefully to make sure of adapting the plant to demands, and securing the best possible combinations.

Matters to be considered include:

a. Adapting buildings to future growth. Later extensions must be considered, which may mean adopting some form of unit construction or an arrangement such that new buildings may be added in a way to fit into an enlarged production program.

b. Selection of type of construction. In doing this an extended knowledge of the best current practice in building modern factory buildings is necessary. Points involved are materials of side walls, type of roof, division of interior into bays according to service possibilities, window lighting scheme, etc.

c. Floor material, considered with reference to service requirements and comfort of workers.

d. Number of floors, working galleries, etc.

e. Necessity of providing supports for traveling cranes and shafting.

f. Fire hazard and facilities for safeguarding against same.

g. Ventilating and heating, air conditioning, running of service steam, water, and gas lines.

h. Artificial lighting system and distribution of power.

i. Special process demands, as for drying, cooking, steaming, washing, etc., calling for segregation.

The study of these structual elements requires the drawing of sketch plans, and making preliminary calculations for structural weights. This calls for an analysis of roofs with sufficient accuracy to establish general dimensions. On the floor plans the routing system for materials should be traced in its main outlines and the principal machines located accurately. Reasonable allowances must be made for working and handling space, and for setting minor tools which might be overlooked in the most careful advance planning of operating needs.

There follows a more detailed discussion of these several divisions of the work, pertaining mainly to machine building or other metal goods manufacture. This is for illustration only, to show methods rather than fully developed problems.

THE DETAILED ANALYSIS OF PROCESS

This will include the elements listed under parts (1) and (2) above, since the determination of space requirements involves study of process methods, equipment, routing, and the administrative plan, simultaneously. It covers production from the receiving platform to the shipping platform, but not the general administrative offices, designing room, or the auxiliary service portions indicated in (4).

It is here that the technical knowledge of the designer is paramount. If the plant is to be one for the manufacture of machinery or any form of metal goods, he will find it necessary to know shop processes intimately. Machine tools have been developed to a high degree of perfection, and, especially in recent years, many refinements in methods and adaptations of tools to special work have revolutionized shop practices. A successful plant designer must be acquainted with all this, as well as with the tool market. The following illustrations serve to show just what is demanded. A few individual pieces will be cited but no attempt made here to follow out an analysis for a complete machine. Such an attempt would extend the discussion far beyond the scope of the present volume.

A. Lathe Bed.—Material, cast iron. May be cast in company foundry or purchased. Practice of leading manufacturers of lathes differs. In either case the casting is assumed to have been well cleaned and made ready for machining.

First machining process—planing: first, bottom side of bed; second, rough planing of top of bed, top and sides of V-grooves; third, finish planing of top complete. Extremely accurate work on lining of beds on the planer is necessary, often performed by a trained specialist other than the operators of the planers. This calls for additional planers on which work is being laid out while others are in operation.

Planers are selected according to size of work. If the plant is to turn out a general line of lathes, long beds must be provided for. It may be best practice to use a stated maximum length in a single piece, building the extremely long beds in sections to be bolted together. This calls for extra steps in machining the connecting ends. Short beds of uniform size are commonly set in tandem on planer beds of large size, thus economizing time of planing operation. The number of planers is determined from

data as to the quantity of output and the time required for the several process steps.

Second main machining process—drilling for bolted connections. Performed on radial drills.

Third step—fitting of legs.

Fourth step (usually on the assembly floor)—hand scraping of the ways and upper finished surfaces.

The general assembly then proceeds in usual routine. This condition calls for a generous allowance for the assembly area. It should be noted that in lathe building the practice is followed of manufacturing small parts to a finished-parts stockroom, from which are issued the units, singly or partly assembled, to the main assembly floor. This modifies the arrangement of manufacturing space, in that the movement of many of the smaller pieces is adjusted with reference to the finished-parts storeroom. Another advantage gained is that small-parts production does not have to be regulated exactly to orders for finished lathes. Parts are drawn from stock as needed at the general assembly. Storeroom stock is replenished on shop orders in production lots, thus keeping a good fraction of the plant operating on a quantity basis.

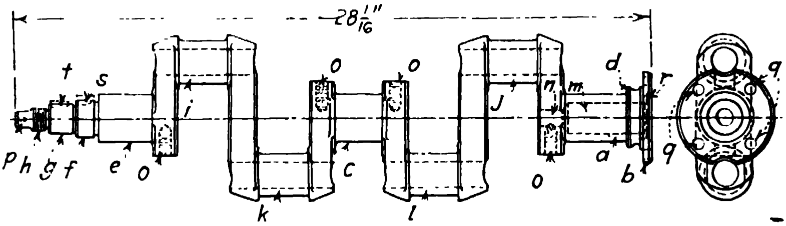


FIG. 2.—Automobile engine crankshaft.

B. Automobile Engine Crankshaft.—This is an example of an elaborate study of operations, for which we are indebted to the magazine *Machinery*. It represents a more complete analysis than may be possible when only advance planning of equipment is the aim, but it represents the ultimate purpose which it is desirable to approximate. The names of builders of the machine tools used are given exactly as in the magazine article, a detail not always necessary in the preliminary design of plant layout. Some of these tools are specially adapted to this service. As a necessary adjunct to the understanding of the analysis, a drawing of the crankshaft is shown. The process begins with the rough forging as received at the machine shop.

ORDER OF MACHINING OPERATIONS

Operation	Type of equipment	Cutting speed, ft./min	Production time, minutes
1 Rough inspection ..	Bench		
2 Heat treat	Furnace		
3 Pickle . . .	Acid tank		
4. Sand blast	Sand blast machine		
5 Straighten . .	Metalwood straightening press		
6 Center both ends .	Duplex centering machine.		
7 Rough turn bearing *a* and outside diameter of flange *b*......	Wickes engine lathe	58	3 16
8 Rough and finish turn the cheek bearing *e*	LeBlond engine lathe	72	5 25
9. Space and turn flange *b*, bearings *a* and *e*, and fits *f*, *g*, *h*, face webs at *b* and *e*, form oil thrower *d* .	Wickes engine lathe	80 to 83	18 12
10 Inspect.	Bench		
11. Cheek webs on all pins, spot turn and space to length pins *i*, *j*, then *k*, *l*.	LeBlond crankshaft lathe	52	14 92
12 Inspect . .	Bench		
13 Cut clearance slots in flange.	Niles-Bement-Pond drilling machine	40	1 20
14 Mill counterweight bosses .	"Milwaukee" milling machine	75	5 35
15. Drill holes *m* and *n* through bearing *a* .. .	Foote-Burt drilling machine	56	6 19
16. Drill 8 holes *o* . .	Baush multiple drilling machine	35	3 00
17 Countersink and tap 8 holes *o*. .	Carlton radial drilling machine	60	3 15
18 Drill axial holes through pins *k*, *l*, *i*, *j*	Foote-Burt vertical drilling machine	40	5 76
19 Wash and blow out 8 holes *o*	Soda tank and air hose		1 25
20 Remove burs .. .	Bench		2 00
21 Straighten . .	Metalwood pneumatic press		2 13
22 Cut to length, recenter both ends, finish turn fits *f*, *g*, *h*, and pilot *p* ..	Monarch turret lathe	75	3 20
23 Tap 8 holes *o* .. .	Air tapping chuck		3 50
24. Rough grind bearings and pins and finish grind the 4 pins.	Landis grinding machine.		
25. Straighten to 0 003 in . .	Metalwood pneumatic press		2 15
26 Inspect	Bench		
27. Finish grind bearings *a*, *c*, *e*, fits *f*, *g*, pilot *p*, and flange *b*	Landis grinding machine		
28 Inspect .. .	Bench		
29 Drill and ream holes *q* in flange.	Baush multiple drilling machine	56	4 18
30. Finish face and chamfer flange *b*, chamfer hole *m* and counterbore at *r* ..	Monarch turret lathe	76	3 60
31 Finish-space bearing *e* and fits *f*, *g*, chamfer and thread at *h*, finish turn pilot *p*	Monarch turret lathe.	40	3 53
32. Mill keyways *s* and *t*.......	Special milling machine	35	1 18
33. Remove burs	Bench		2 00
34. Polish bearings, *a*, *c*, *e*, and pins *i*, *j*, *k*, *l*.....	South Bend lathe.	.	3 38
35. Final inspection	Bench		
36. Weld forging defects	Acetylene torch		29 00
37. Finish grinding as necessary after welding; also straighten			
38. Finish grind and space fits *f*, *g*, *p*....	Landis grinding machine		

C. Piston for Automobile Motor.—This represents the practice in a well-known company, and will apply for similar work in many engine building plants.

Operation	Type of Equipment Used
1. Rough inspection of forging.	
2. Rough turn outside diameter, face the enclosed end, and rough turn the ring grooves.	Gridley automatic.
3. Rough bore the open end and face to length.	Fay automatic.
4. Rough drill wristpin holes.	Special Hoefer drilling machine.
5. Heat treat to remove machining stresses.	Gas or oil furnace.
6. Sand blast inside.	Panghorn sand-blasting machine.
7. Finish bore and face the open end and recenter the closed end.	Fay automatic.
8. Finish turn outside diameter and ring grooves, face closed end.	Fay automatic.
9. Recenter the open end.	Special center-grinding machine.
10. Rough grind outside diameter.	Fitchburg grinder.
11. Rough and finish bore and ream wristpin hole.	Warner and Swasey hand screw machine.
12. Hand ream wristpin hole.	Bench.
13. Face wristpin bosses.	Whitney hand-milling machine.
14. Mill oil-grooves in wristpin holes. (This sometimes done by broaching.)	Sipp drilling machine with National oil-grooving tool.
15. Grind clearance on sides of cylinder.	Norton cam-grinding machine.
16. Drill oil holes from lower ring groove diagonally to wristpin hole groove. (In some pistons this ring groove is chamfered on lower side to receive oil.)	Avey sensitive drilling machine. Special fixture required.
17. Hand-ream wristpin hole to remove burrs.	Bench.
18. Finish grind outside diameter.	Norton grinding machine.
19. Inspect.	Bench.

D. Operations in Manufacture of Drop-forged Tools.—The data apply to small parts of drop-forged tools which can be handled in quantities. Certain special processes, such as knurling handles, will introduce variations, and heat treatment will likewise vary with the use to which the tool is put.

Making of the dies is really a separate process, calling for equipment consisting of vertical mills, shapers, and planers.

Specially designed die-sinking machines are available. Material used for dies includes high-carbon steel and chrome nickel steel. The process is called "die-sinking." Dies are hardened in furnaces so constructed as to be adapted to handling heavy blocks and in appropriate quenching tanks.

Operations on tool material	Equipment used	Daily output per worker
Forging . . .	Board drop hammers of capacity 800 to 2,000 lb. Several makes available. (Furnaces for heating provided at each hammer, commonly oil-burning; several makes available; stock cut to about 7-ft. lengths, calling for stock cutters.)	1,500 to 2,500, according to size and complexity of forging.
Trimming, to cut away the "fin" of steel forced out between die blocks. (Punching, if called for, may be done at same time.)	Pattern presses, "Stiles" type commonly used: various makes.	4,000 to 4,500.
Annealing, if required...	Furnaces of common pattern.	
Pickling, to remove scale....	Vats of sulphuric acid.	Unlimited.
Machining steps, drilling, slotting, milling, broaching, punching, etc.	Common forms of machine tools as suggested by the steps required.	Variable—may be 800 to 8,000.
Making small pins, bolts, etc.	Automatic screw machines, various makes.	800-4,000.
Fitting and assembling.	Bench.	
Carbonizing	Furnaces with carbon-bearing material.	Unlimited.
Grinding, polishing, buffing, plating.	Grinders and special "jacks," plating tanks.	

E. Die-casting Plant.—Another interesting metal products industry is that of die-casting, for turning out relatively small articles in various metals and alloys. White metal, brass, and

aluminum and aluminum alloys figure largely as metals. The products vary largely in type, many automobile and aeroplane parts being made from the light-weight alloys. The business of casting such articles is becoming an extensive one.

The accompanying figure shows a typical plant layout for miscellaneous goods of this character. The most important parts

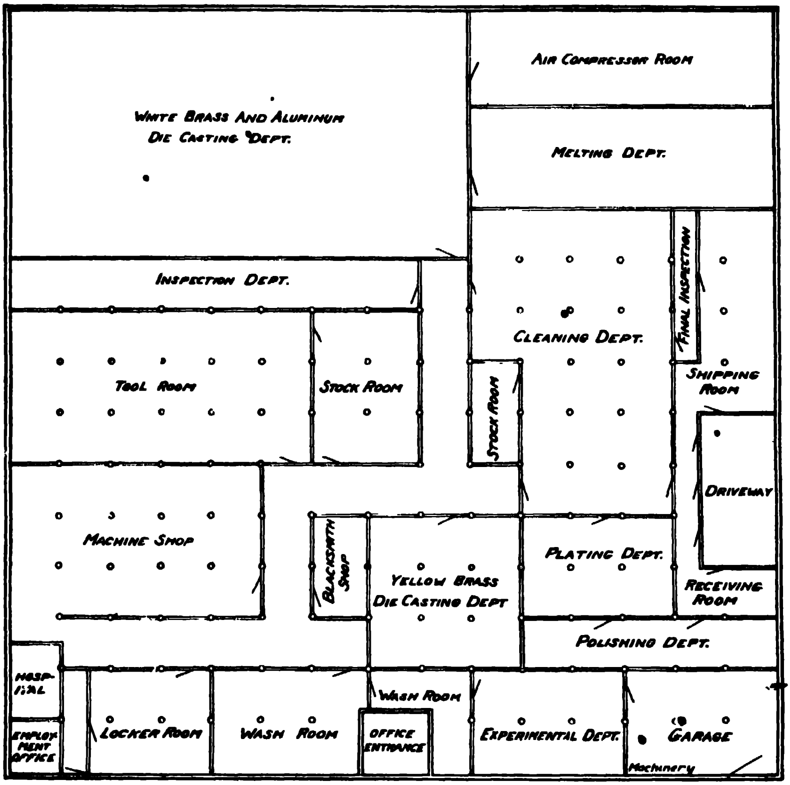
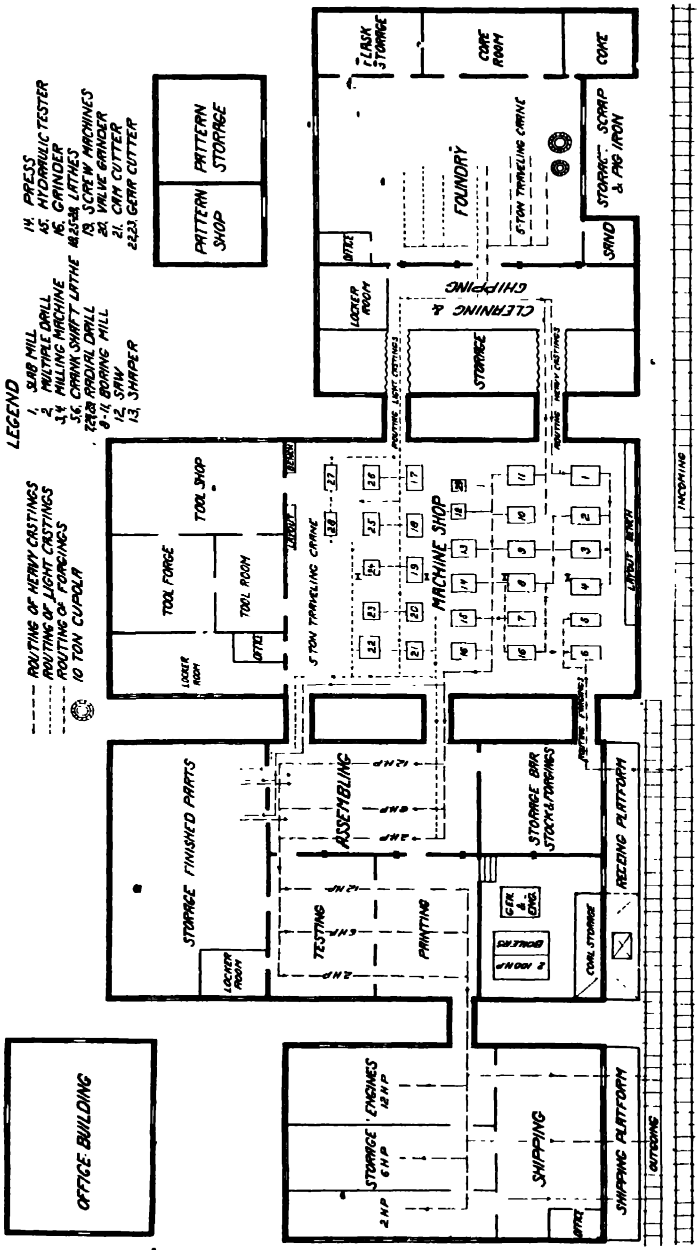


FIG. 3.—Die-casting plant.

of the working space are devoted to the casting and melting processes, cleaning of the castings, and the machine shop and tool room, devoted mainly to the making of the dies. Die-casting machines are used almost exclusively, 125 being installed in this plant. Compressed air is employed extensively, both for forcing the metal into the dies and for operating the machines.

The front section of the building has a second floor accommodating the general offices and designing rooms. The remainder



PROPOSED PLANT FOR BUILDING SMALL GASOLINE ENGINES

Fig. 4.—Design for engine building plant.

is one-story, with saw-tooth roof. (For further descriptions of this plant the reader is referred to *Machinery* for October, 1919, to which magazine the author is indebted for the illustration.)

F. Small Engine Building Plant.—The second plant layout, Fig. 4, is a new design for a hypothetical establishment for building a simple type of small gas engine. The designer has followed through the prescribed methods of analyzing the process steps in making each individual part of the engine, and has developed a routing plan that is shown clearly in the drawing. As drawn, the plant is divided into four separate buildings with covered connecting passages. This was done to give sidewall lighting. A somewhat more compact arrangement would be to throw the space into one large building with saw-tooth roof, similar to that used in the die-casting plant of the preceding illustration. This design was developed by a senior mechanical engineering student in regular class work, purely as a routine exercise, under the direction of the author.

The foregoing notes and illustrations give the general outlines for the process of designing the physical plant in respect to process needs, in the field of metal products. The importance of the routing diagram is readily apparent. Stock-receiving and finished-goods shipping facilities, with reference to transportation lines, are matters pressing equally on the attention of the designer. Measures taken for placing the tool room and shop administrative office so as to secure direct contact with the operating departments are indicated in the illustrations. In the successful handling of these questions lies the opportunity of the designing industrial engineer to establish the basis of economic production. The ultimate aim is not realized in this alone, because the improvement of operating methods is a never-ending process of development, predicated on studies of processes which cannot be completed until the plant is in service, with all tools and machines running. But the initial plan, if well made, forms the groundwork for a truly effective system of operation—economical because effective. It is basic to low-cost production, because it is the one and only method whereby original investments may be adjusted correctly to the actual needs of the enterprise, thus enabling the management to plan consistently and adequately in matters of finance.

Similar studies are applicable in plants for furniture, leather goods, men's hats, tobacco goods, and others wherein workers

handle the materials, and, by the processes under their control, determine both amount and quality of output. For another group of industries, in which materials follow paths fixed absolutely by equipment, and workers are dominated by equipment characteristics, a somewhat different procedure is demanded. Such industries comprise most of those in the second and third groups listed in Chapter I. One of these will now be considered in detail.

COTTON GOODS MANUFACTURING

In the preceding chapter, woolen goods production, rather than cotton, was considered as to process, so that in the present connection some terms will be used which have not been defined. While all the textiles are similar in their producing characteristics, each branch has its peculiar nomenclature. It is not the thought to give here an adequate treatment of cotton mill design, on which engineers might proceed to lay out mills of varying types, but rather to illustrate the form of study of mill equipment that is necessarily made in order to secure a coördinated mill outfit that will operate in effective manner in industries wherein material follows the strict demands of process equipment, and output is determined solely by that equipment.

The main outlines of this treatment of the subject are borrowed from the "International Library of Technology," Volume 78, from which are taken directly the illustrations of mill machinery layout given in Figs. 5 and 6, through the courtesy of the publishers of that valuable series of works.

No attempt is made to give details of methods, nor the fine distinctions in the machines fitted for the production of the various types and grades of yarn. There are intricacies of process all the way through, from the first carding and combing steps on, past the several kinds of spinning and drawing machinery, to the weaving. A plant designer must be familiar with these various processes before he can make selections of equipment with accuracy. To discuss these many phases of the work would require several volumes. The varieties of yarns in the cotton branch alone are numbered by hundreds—even thousands when all classes are included. Some of these are distinguished only by the number of twists per inch given in the spinning, but this difference is accomplished through the specification

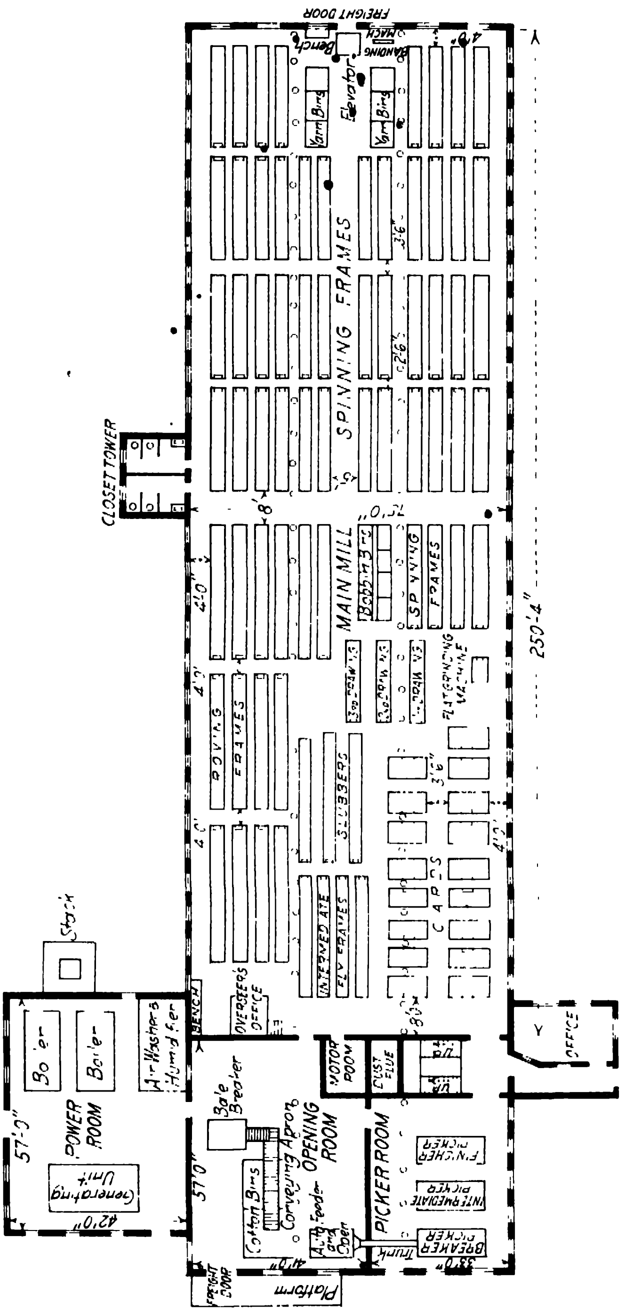


FIG. 5.—Machine layout for cotton mill, first floor.

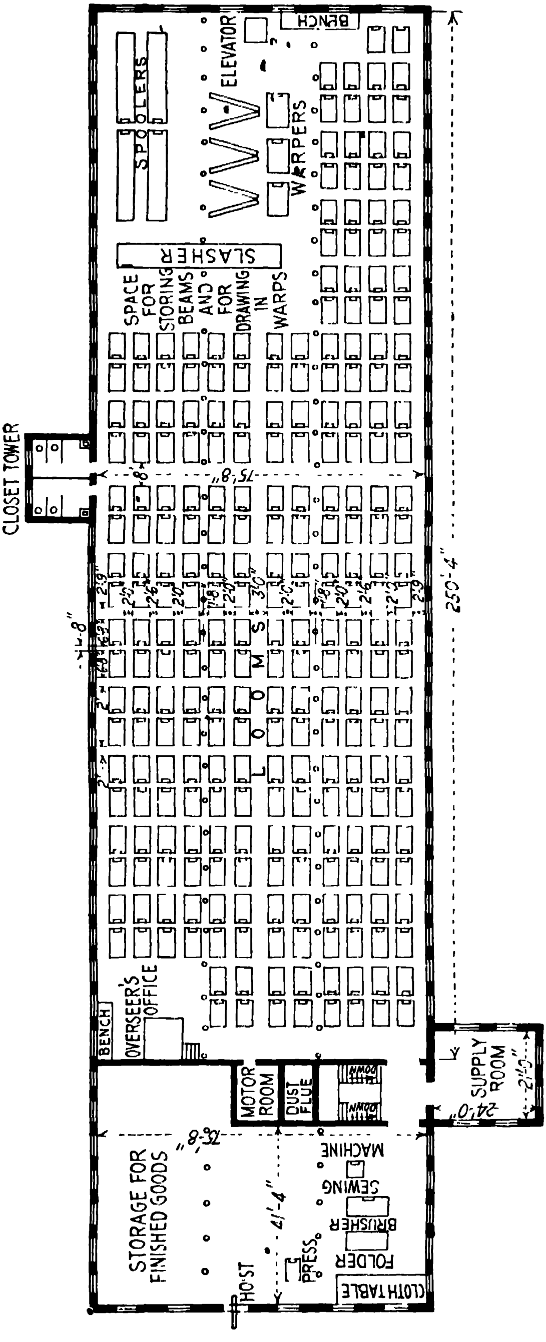


FIG. 6.—Machine layout for cotton mill, second floor.

on which the machines are built. This is a technical difference with which only the experienced specialist can deal.

The problem may be stated thus: It is proposed to build a mill for the spinning and weaving of cotton goods of the medium-weight class, known as "print cloth," weighing 4 yd. to the pound, 39 in. in width, made up from warp yarn No. 28 and filler No. 36. This kind of cloth is made in great quantity. Further specification is that the cloth shall be of 72 sley and 80 picks to the inch, the reference being to the number of threads of warp and filler respectively. The capacity will be taken at 10,000 spindles in the spinning room.

The weight of yarn produced per spindle varies with the number of the yarn and the twist. For warp No. 28, with 25.13 twists per inch, the output is 0.244 lb. per spindle. For filler No. 36, with 19.5 twists per inch, the output is 0.194 lb. For 5,000 spindles for each, the output will be 2,190 lb. per day. The division between the two yarns, on the basis of an equal number of spindles employed, is sufficiently close to the weights of the two as they enter into the fabric to make finer calculations unnecessary. For a 6-day week, allowing for 10% loss, 5 in the carding and 5 in the pickers, it is found that the weight of cotton to be handled by the breaker picker is 14,559 lb., and that by the finisher picker 13,832 lb. per week. Allowing for a 10% increase in the weight of the warp for sizing, we have $0.244 \times 5{,}000 \times 1.10 \times 6 = 8{,}050$ lb. to be woven. The weight of filler is $0.194 \times 5{,}000 \times 6 = 5{,}820$ lb. The total is 13,872 lb. of cloth, or, at 4 yd. to the pound, 55,488 yd.

It is now necessary to find the number of machines of each of the several kinds used. This calls for accurate information as to the capacity of standard makes of machines. For example, a standard loom operating at 80 picks to the inch will produce 208.125 yd. per week, calling, therefore, for 266 looms in the mill. In the initial process, where bales of cotton are broken and the cotton made ready for the picking process, a single machine has a capacity greater than is required. The single breaker would be taken as it is built by the manufacturer, even though it has surplus capacity, rather than have a special size built. Thus it happens at several steps that the plant will have surplus capacity where fractional numbers of machines, when taken at exact capacity, are found to be sufficient. Tables and other data are furnished in the volume of the "International

Library" above referred to, showing exactly how each step is provided for. Further details will not be cited, but the reader who is interested in this class of design is referred to that or some similar work. The data there given were according to conditions several years ago, and so are subject to revision. The following table carries the full list of machines which would be needed to equip the mill. With them is included certain auxiliary apparatus for handling material and adjusting process equipment.

1 Bale breaker and conveying apron.
1 Automatic feeder and opener.
1 Breaker picker, two sections.
Cleaning and connecting trunk.
1 Intermediate picker.
1 Finisher picker.
17 Revolving flat cards.
2 Card-grinding dead rolls.
2 Card-grinding traverse rolls.
2 Stripping rolls.
1 Machine for clothing cards.
1 Flat grinding machine.
First drawing, 1 frame, 2 heads, 6 deliveries each.
Second drawing, 1 frame, 2 heads, 6 deliveries each.
Third drawing, 1 frame, 2 heads, 6 deliveries each.
2 72-spindle slubbers.
5 90-spindle intermediates.
14 136-spindle roving frames.
48 208-spindle spinning frames.
1 Banding machine.
4 100-spindle spoolers.
5 Warpers with creels.
20 Section beams.
1 Slasher.
1 Kettle with overhead track, for sizing warp.
4 Drawing-in frames.
266 Looms.
1 Sewing and rolling machine.
1 Cloth brusher.
1 Cloth folder.
1 Baling press.

Figures 5 and 6 show the arrangement of these machines on the two floors of a building adapted to the business according to established practices in cotton mill planning several years ago. Later practice would provide somewhat more generous working space around the machines, with more attention to lighting. A narrower building provides better ventilation as well as sidewall lighting. This would call for either a third floor or a double building arrangement, the latter making it possible to separate the equipment used for the warp and filler through the roving, spinning, and spooling operations and providing for better supervision. Power generating and application methods have also undergone changes, with the more extended use of electric

motors. The plans shown give a good idea of space requirements, from which other layouts could be devised.

The method of procedure here outlined for cotton mill analysis is representative of what must be done in planning for a great many industries. Balance in machine capacities in the several process steps is a prime element. Accurate work at this point is essential in securing smooth operation and a minimum of investment.

INFLUENCE OF MANAGEMENT SYSTEM

As before noted, the form of administrative plan has an influence on the layout of rooms and equipment. The characteristics of management methods referred to are:

> A closely drawn system of instructing workmen as to methods of operating the machines, with specified cuts, feeds, and speeds, standardized tools, and a complete plan of instruction card writing; as opposed to the older plan of leaving much to individual workmen.
>
> Division of the force into specialized groups with gang bosses carrying most of the responsibility - a feature of the first alternative noted above, although not necessarily with a general shop plan for specifying exact methods of work.
>
> A system of keeping production records and other statistical data in accordance with the several divisions of the process work.
>
> The stockroom system with respect to the storage, issue, and follow-up of material, affecting principally the size and arrangement of the room.
>
> System of checking workers in and out of the plant, affecting the locating of entrances and exits, locker and wash rooms.
>
> The plan of work with respect to movement of finished parts, whether direct to the assembly or to a finished-parts storeroom on large production orders, and thence, as required to the assembly.

It is clear that decisions on most of these matters are dependent on the character of the product and size of establishment. They must be determined upon when the general manufacturing plan is being formulated. Probably the industrial engineer engaged on the design of the plant has had much to do with the formula-

tion of these plans, but, if not, he must have complete information regarding them.

An illustration of the way in which the sales and production departments may coördinate is afforded by the practice of one of the large builders of Diesel engines. Although this concern builds no engine costing less than about $18,000, it never puts an order for a single engine through the plant. Duplicate parts for not less than four or five engines are made in lots, all except those for the single sale order going into storage. The storage space requirements for such a plant are manifestly much greater than for those following a different policy. Naturally, the sales force lend their efforts to the securing of orders for units in groups, and are enabled to guarantee quicker deliveries on sizes which are already manufactured in large part, a circumstance often of great assistance in placing an order.

Another matter calling for consideration, and one to which progressive manufacturers are beginning to give attention, is that of training apprentices. Rooms for class instruction are provided in many cases, and occasionally special shop rooms are seen, outfitted with a varied assortment of tools, on which boys are given instruction. This practice insures a more general training than could be given in the production departments, with less spoiled work resulting therefrom. In the Sante Fé Railway shop system an effective and complete apprentice school is maintained. Other railroads are following similar plans. In Volume 27 of *Machinery* is a series of articles outlining in detail the training methods in use by the Norton Grinding Company. Some of the larger machine tool companies of Cincinnati are giving the matter careful attention. It is something on which the future of the metal products industry depends in great measure.

Many of these elements of the management plan are discussed more fully in the chapter on "Personnel Administration" in Part II.

SELECTION OF LOCAL SITE

The questions to be considered have been listed on page 112, following which certain possible auxiliary service demands are mentioned. All of these points must receive consideration.

In order to make the discussion definite, an actual city map is shown as a type (Fig. 7). It is the map of Hutchinson, Kansas,

a city of about 24,000 population, with industries employing 2,900 people, of whom 2,350 are men. The ratio of men to women workers is 4.31, a relative low ratio, which suggests the desirability of a new establishment employing men in large

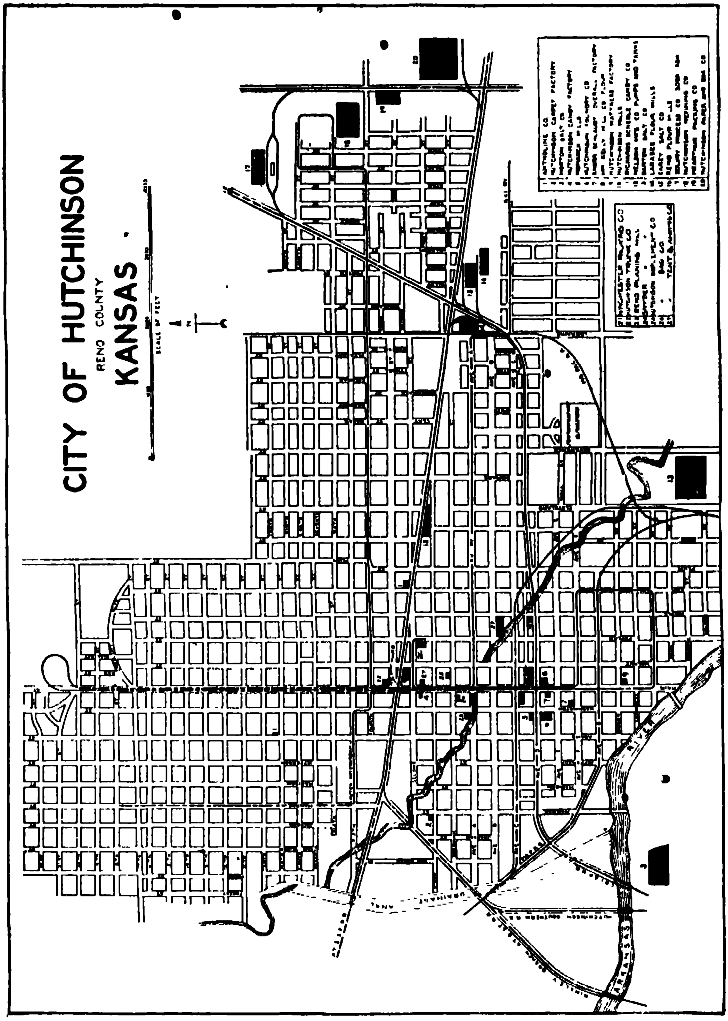


FIG. 7.—Map showing locations of industries.

proportion. Such a plant will be assumed, namely, a concern for manufacturing a miscellaneous line of metal goods, mainly tools and supplies for the garage trade. Hutchinson is an important trade center, serving a large territory to the West, and South-

west. Two main lines of railroad reach directly into those regions, the Santa Fé main line to the West, and the El Paso branch of the Rock Island to the Southwest. A third road, the Missouri Pacific, gives connections southeast and northwest. It is the center of the Kansas salt industry, and of a rich agricultural region producing wheat in great quantity, also apples and other fruits on a scale that is notable for the Middle West. It is a heavy shipping point, having many miles of track in the yards.

A distinctive feature is the passing of all of the railroads through the center of the business district, which is laid out attractively. The larger industries are on the outskirts to the east and south, where the ground is level and but little above the flood plain of the Arkansas River. The natural residential development is to the north, due to topography as well as to the occupation of the other sections by the railroads and the industries. There is a growing section, mainly workmen's homes, to the southeast, south of the A.V.I. Railway (Arkansas Valley Interurban).

The water supply conditions are unique, in that the river is of lesser significance than might be assumed. At certain seasons of the year the visible amount of river flow is small, the water settling into the underflow. Ground water is abundant across the full width of the valley, extending several miles on either side, and is only 15 to 30 ft. below the surface. This explains why many of the plants demanding large quantities of water are located at considerable distances from the river. The salt bed is several hundred feet lower, so there is no contamination of the water, which is of good quality.

The most ideal location, from the standpoints of proximity to railway lines, workers' residence section, and street car system, is along the A.T. & S.F. Ry., just east of the industries marked on the map as numbers *15* and *16*. Near this point all three of the railroads already have switching lines. Any available piece of ground, reasonable in price, for a distance of a half mile, would answer the needs. The proposed plant is one without obnoxious wastes, and one needing only the ordinary service of sewage systems, so no questions arise on these scores. Almost equally well situated is land in the vicinity of the Solvay Company plant, number *17*. Another good site is just west of the drainage canal, near the crossing of the A.T & S.F. and the Mo. Pac. roads, the only disadvantage being distance from street car lines.

The problem is a simple one in a town such as the one shown by the map, but the process to be followed in making a selection is well demonstrated by it. In many of the large industrial centers it is impossible to find sites which meet the tests at all adequately, the result being that special provisions must be made. Civic development agencies in some cases have built belt-line roads to serve designated industrial areas in order to extend the limits. In other cases entire new communities have been built up by one or more industries, illustrations of which may be seen at Chicago, Philadelphia, Cincinnati, and Detroit. Each community presents a problem peculiar to itself, and we may present with profit only these illustrative suggestions.

With reference to the auxiliary service demands, it may be remarked that not until the plant is of considerable size, employing nearly a thousand workers, will space for outdoor recreation in the line of athletics come up for consideration. The wise planner will hold such possibilities in mind, however, and see to it that enough land is available. A somewhat similar statement may be made regarding the building of a separate office building. Other matters in this category involve only interior planning, with but slight effect on the extent and character of the site.

DESIGNING THE BUILDING

The exact floor space requirements, it is assumed, have now been determined. There remain the many questions pertaining to the ways in which the physical structure may be adapted to the demands, most of which have been suggested on a preceding page. Without going into the technical designing of structures, a few observations will be made as to conditions that affect the building as a shell which houses a functioning institution. For the strength design and proportioning of parts the reader is referred to Ketchum's "Design of Mill Buildings." There are many suggestive discussions, also, in the book on "Mill Buildings," by H. G. Tyrrell, mainly on details of construction, although the changes in costs which have come about in the past 10 years lessen the value of data which form a considerable portion of the the book.

The modern mill building is characterized by large window areas and forms of roof construction providing still more window lighting. Sidewalls are commonly of reinforced concrete or

brick, varied by a combination construction of steel frame with concrete on expanded metal. Roofs vary widely as to form, according to the extent of the lighting demanded. When the width is such that sidewall windows afford sufficient light, a simple pitched roof with a monitor having ventilating windows is a common form. Steel framing is almost universal. The roof covering may be corrugated metal on steel framing, flat metal on wood planking, reinforced concrete slab, or tar and gravel on planking or concrete. For buildings of widths greater than 60 ft., the saw-tooth construction is commonly used when the work is of a character requiring effective lighting. The back slopes of the roof sections are covered as noted above. Such buildings are usually of single story. In choosing between single-floor and multiple-floor buildings, in cases when the service is for light material which might be handled on different levels, one must be guided by the facts that, on the one hand, the investment is less for multiple floors in proportion to actual floor area secured, while, on the other hand, the effectiveness of labor in manufacturing is greater by from 5 to 10% when carried on on one floor. These figures will vary with different kinds of work, however, and the value of land is another factor of significance. An accurate study of costs is necessary in finding the correct solution.

An important consideration is that of lighting. It must be treated under two separate heads: natural daylight and artificial lighting systems. It must be observed at the outset that when artificial lights are necessary to supplement daylight, for illuminating dark spots or to give more intense light locally, where especially delicate work is being performed, the requirements are different than for the illumination of working areas used during the night. This is because the eye is adjusted to daylight conditions during the day and more light is required than at night when the eye is in a different state.

Several definitions, basic to all lighting sources, must be given in order to state the conditions scientifically.

The unit of light is the *lumen*. It is an absolute quantity factor. One lumen will light a square foot of surface to an average intensity of 1 foot-candle.

The degree of illumination of a surface is measured in *foot-candles*. It is an intensity factor.

The fraction of the total lumens, generated at the source, which actually reaches the surface to be illuminated is known as the

coefficient of utilization. It depends upon the diffusing and reflecting equipment, color of walls and ceilings, size and shape of the room, and the height of the source above the plane of the work.

In calculating artificial lighting systems, allowance must be made for the deterioration of lamps by aging and also from the collection of dust on reflectors and on walls and ceilings. In doing this, a *depreciation factor* is used. It may be likened to a factor of safety.

The requirements of good illumination may be variously stated. The main points are:

1. A steady light of the proper intensity on the surface where work is being done. It must be noted that intensity is different, in general, on vertical surfaces than on horizontal. This means that the position of the surface must be stated accurately, since most of the recorded data refer to a horizontal plane and it is necessary to adjust to demands on the vertical. When the light comes from above, the intensity will be from 15 to 40% greater on the horizontal than on the vertical. When coming from side windows, it may be reversed at points near the windows.

2. There should be comparable intensity on adjacent areas. This is equivalent to saying that there should be good diffusion. If light is strong on the working surface, from local sources, while floors are poorly lighted, workmen are liable to discomfort when moving about, because of the necessity of adjusting the eyes to different intensities. Accidents are more frequent and loss of time is suffered.

3. The color and spectral character of the light should be suited to the purpose. This pertains solely to artificial lighting, of course, in which the effort is made to approximate to daylight characteristics. Special efforts are necessary when colors are to be matched in the work. Blue-green glass bulbs on incandescent lamps, and the mercury vapor light, give tones adapted to this condition. In a smoky atmosphere, as in foundries, light in which red and yellow rays predominate is more effective.

4. There should be freedom from glare.

5. Shadows or contrasts of intensity are objectionable.

In daylight an intensity figure of 100 foot-candles may be taken as an average, on surfaces exposed directly to the sky. On clear days it is more. In passing through windows a loss of about 25% occurs. The effective part of the window is that through which

the sky is visible, which explains the need for high windows. For work near windows the lower portion should be shaded.

When one window supplies the light, the intensity on the working surface varies approximately with the inverse square of the distance from the window. As actually constructed, however, buildings commonly have many openings both in the sidewalls and in the roof, so that the rule as to the square of the distance does not apply directly. Intensities vary widely, of course, from a combination of causes, such as width of rooms, presence or absence of glass roofing of the saw-tooth order, the natural variation coming from weather conditions, color of walls and ceilings, and color and texture of the material being worked on. The figures, under what have been pronounced satisfactory conditions, vary from 4 to 50 foot-candle intensity. The following table gives the records of many observations, each observation having been made at a time when lighting was considered satisfactory for the class of work under way. In all cases in this table, sidewall windows only were in use. The intensity given is that for a horizontal surface. On a vertical surface facing the source of light, the intensity is in most cases twice that on the horizontal. On vertical surfaces away from the light, it varies from 10 to 60% of the horizontal. With saw-tooth roof lighting, these relationships would change materially.

INTENSITIES OF DAYLIGHT ILLUMINATION IN FOOT-CANDLES, HORIZONTAL SURFACE

Factory product	Grade of work		
	Fine	Medium	Rough
Machine tools	10	9	6
Machine forgings	..	6	5
Special machinery	9	6	3
Automobiles	5	5	5
Storage batteries	..	5	3
Sheet-iron parts	10	5	8
Clothing	10	4	
Furniture	5	5	

A general average of observations, involving many more than in the above table, shows satisfactory conditions to require intensities of 10, 7, and 5, respectively, for the three grades of work. The better the degree of diffusion attained, as also the higher reflecting properties of the material being worked upon, the lower the intensity permissible.

Unfortunately, the data on daylight illumination are not complete in the facts as to floor and window areas for which stated intensities may be estimated. Most of the scientific work done has related to artificial lighting. We can do nothing, therefore, but fall back on general relationships stated in other terms. This means, virtually, limiting the widths of rooms lighted entirely from side windows to from 40 to 60 ft., depending upon the height of ceilings and the grade and color of the work. In general, window area will be made as large as construction conditions permit, remembering that the area below the level of the work is practically useless. In fact, window area below a line 4 ft. above the floor is of little use. Windows in the sidewalls of monitor projections of roofs, where the height is 30 ft. or more, as is usually the case, do not add to illumination in proportion to the area. In most buildings with the monitor type of roof, the windows are likely to become clouded with dust and smoke and their effectiveness reduced still more. Their value is largely for ventilation.

If the width of the building is such that saw-tooth or north-light roof construction over a single floor is to be used, the following considerations apply:

Roof truss spans carried directly on columns should be not over 40 ft., but may run to 60 ft. For this greater span and over, the rafters should be supported on beams or trusses running either transversely or longitudinally, the span of each roof section being one-half or one-third of the column spacing. This will bring the roof spans to 20 ft. and more. It is the opinion of the author that if space requirements on the floor make column spacings under 50 ft. undesirable, this latter form with beams running north and south should be adopted. With two roof sections, this brings the span 25 ft., which gives a good height for the glass slope of the roof.

The angle of slope of the glass, measured from the vertical, should be as great as possible without admitting the rays of the

sun in the long days of summer. An angle of 25 or 30 deg. is usually satisfactory.

The width or height of the glass, measured along the slope, may be from one-fourth to one-third the saw-tooth span, for good illumination.

Care must be taken in construction of the gutters. Downspouts are provided at the columns, those from valleys at the center of the span of the supporting beam, where the divided span is adopted, being carried to the columns on a good incline. A 3-in. downspout will drain 1,000 sq. ft. of roof. Steam heating pipes should be carried along under the gutters, to prevent freezing. These pipes form part of the regular heating system.

For more complete descriptions, and for details of construction, see Tyrrell's "Mill Buildings."

Artificial Lighting

The available sources of data on artificial illumination are mainly the publications and files of the manufacturers of lamps and other lighting materials. Two bulletins of the National Lamp Works of the General Electric Company, Numbers 20A and 41, dated September 10, 1919, and January 15, 1921, respectively, are especially useful in detailing methods of designing systems for industrial plants.

A general condition, which has been mentioned and which has an especial bearing on artificial lighting, is the economic effect of good illumination. Up to the limits where results comparable to good daylight are being secured, expenditures for lighting are more than repaid by the increased production from workers. In addition to this, there is the saving in accidents and workers' compensation.

In plants where material is transported by traveling cranes it is necessary to employ lights set above the crane level. This means large mounting height, affecting the coefficient of utilization of light capacity. Incandescent lamps must be equipped with reflectors, of which there is a multitude of forms and kinds. Mercury vapor lamps have their own special determining factors. The finer classes of work should be arranged for in portions of the plant where there is clear space to set the lights at a more effective height. Only for the most exacting grade of work should local lights, set close to individual working surfaces, be allowed.

Where this is done, there should be good general illumination, so that when the eyes are turned away from the work they may not be subjected to violent changes.

The following is from *Bulletin No.* 41, National Lamp Works:

Standards of Illumination
(Intensities in foot-candles)

Character of Service	Foot-candles Recommended. Variations Allowable with Varied Colors of Walls and Work, Etc.
Auxiliary spaces, aisles, corridors, stairways, etc	1 to 2
Machine shops:	
Rough bench and machine work..	6
Medium bench and machine work, rough grinding, medium buffing and polishing	10
Fine bench and machine work, fine automatic machines, medium grinding.....	12
Extra fine work, fine grinding	12 and up
Foundries:	
Charging floor, tumbling, cleaning, etc	5
Molding and core-making	6 to 10
Forge shops:	
Rough forging	6
Fine forging and welding	10
Machine assembling:	
Rough............	5
Medium	8
Fine..	10
Power plants:	
Boiler rooms.......	3
Engine and generator rooms	6
Auxiliaries, switches, etc.	5
Offices........	10
Drafting rooms....	15
Paint shops:	
Dipping, spraying, firing........	5
Ordinary hand painting	8
Fine work, automobile bodies.	10 to 15
Steel mills:	
Soaking pits, reheating furnaces..	2
Charging and casting floors..	3
Rolling, shearing, cleaning, etc	4
Light and cold rolling, wire drawing, fine shearing	6
Textile mills (cotton):	
Opening, carding, roving.........	4
Spinning, warping, weaving.	8

STANDARDS OF ILLUMINATION (*Continued*)
(Intensities in foot-candles)

CHARACTER OF SERVICE	FOOT-CANDLES RECOMMENDED. VARIATIONS ALLOWABLE WITH VARIED COLORS OF WALLS AND WORK, ETC.
Textile mills (woolen):	
Picking, carding, combing	4
Twisting and dyeing	6
Drawing, warping, light goods	6
Drawing, warping, dark goods	10
Weaving light goods	8
Weaving dark goods	12
Knitting machines	10
Cloth products:	
Light goods	10
Dark goods	15
Leather manufacturing:	
Vats	3
Cleaning, tanning, stretching	4
Cutting, fleshing, stuffing	6
Finishing and scarfing	10
Shoe manufacturing:	
Hand turning and miscellaneous	8
Inspecting and sorting material, cutting, lasting (light)	10
Ditto, including stitching (dark)	10 to 20

With the intensity of illumination at the working surface determined, and the general type of light selected, one may now determine the number and spacing of lamp units and their height above the plane of work. An illustrative example will be given, taken mainly from *Bulletin No.* 41, National Lamp Works, which typifies an ordinary shop installation where the overhead space is not needed for crane operation.

The building, or room, is 60 by 120 ft., with a height of 12 ft. to the trusses. This permits placing the lamp 11 ft. above the floor, or 7½ ft. above the plane of work. For the type of lamp of the National Lamp Works make that is adapted to this service—the RLM dome with bowl-enameled lamp—the tables show a maximum spacing of 11 ft. The room divides better with a spacing of 10 ft., giving six rows of lamps with 5 ft. clearance from the wall on each side. Each light, therefore, will serve 100 sq. ft.

To find the lamp lumens required per square foot of lighted area, multiply the foot-candles of intensity by the depreciation factor, and divide by the coefficient of utilization. These terms have been defined on a preceding page.

The general rule is to use a depreciation factor of 1.3 for locations reasonably clean and 1.5 for more dirty and inaccessible locations. The room is one for medium-grade machine assembly work, under good conditions, calling for 8 foot-candles at the working level. Hence the factor, 1.3 is applicable.

The coefficient of utilization is a more variable item. Tables are given in the bulletin, space for which is not available here. In general, it may be said, however, that for rooms of this type, for a height of lamp from 7 to 9 ft. above the work plane, and the Mazda-type of lamp with good bowl reflector, the coefficient will be within limits of 0.53 and 0.6, where the ceiling is fairly light in color and the walls fairly dark. As walls get darker, use the lesser values. For this instance, 0.57 is used. From this we have—

$$\text{Lumens per lamp} = \frac{8 \times 1.3}{0.57} = 18.2 \text{ per square foot.}$$

Total lumens per lamp then equals 1,820.

According to the table of the National Lamp Works this calls for a 150-watt Mazda lamp, rated at 2,040 lumens as the nearest standard size. The number of lamps for the room is 72, according to the spacing already designated.

Had a traveling crane required the lamps 23 ft. above the floor, the spacing would have been 30 ft., or 900 sq. ft. per lamp, the coefficient of utilization would be 0.49, and the lumens per lamp 19,150, calling for 1,000-watt Mazda lamps.

This serves to illustrate the method of computation. Tables must be resorted to for unusual cases.

Similar rules apply for the mercury vapor form of lamps. Data furnished by the Cooper-Hewitt Electric Company show that their Type *F* lamps, set 8 ft. above the work and spaced 20 ft. horizontally, will give an intensity of 9.9 foot-candles. The watts per square foot of floor area under this condition is 1.1.

These quantities are read from the table below, which is from Bulletin 202 of the Cooper-Hewitt Company. Type *F* is the lamp using alternating current. For their Type *P* lamp, using direct current, deduct 10% from figures for intensity as given in the table. This means that if one is looking for a spacing which will give a prescribed intensity, one must look in the table for a figure 10% greater than that required. It is to be noted

that results indicated in this table apply to a system of not less than 16 lamps. This insures full utilization of the angular rays.

INTENSITIES PRODUCED BY 16 TYPE *F—EC* COOPER-HEWITT LAMPS SYMMETRICALLY SPACED

Height	Horizontal distance between lamps											
	8	9	10	11	12	13	14	15	16	18	20	24
4	59.7	43.8	26.6	25.0	19.5	17.1	12.8	10.5	7.6	6.2	4.2	1.5
5	67.5	60.2	43.0	30.0	23.5	21.5	16.7	13.3	10.0	8.0	5.8	2.5
6	70.8	63.7	46.2	33.4	26.6	24.6	19.3	15.5	11.9	8.5	7.2	3.5
7	70.8	63.5	48.1	35.8	28.8	27.2	21.0	17.3	13.6	10.8	8.3	4.4
8	69.7	62.4	48.8	37.2	30.6	29.6	22.7	18.8	15.1	12.0	9.9	5.1
9	67.5	60.0	47.6	37.8	31.7	30.4	23.9	19.9	16.4	12.9	10.4	5.7
10	64.8	57.6	46.0	37.3	32.2	30.0	24.8	20.6	17.4	13.8	11.0	6.3
11	62.0	55.0	44.3	36.2	32.1	29.3	25.0	21.1	18.0	14.4	11.7	6.7
12	58.8	50.0	42.6	35.1	31.5	28.5	24.5	21.2	18.1	14.9	12.2	6.9
13	55.6	49.5	41.0	34.0	30.7	27.7	23.9	21.1	18.0	15.2	12.3	7.1
14	52.1	46.5	39.3	32.8	29.8	25.8	23.1	20.8	17.8	15.4	12.4	7.2
15	48.3	42.0	37.7	31.6	28.9	25.8	22.5	20.3	17.5	15.3	12.4	7.3
16	44.1	37.6	36.0	30.4	27.9	24.9	21.0	19.8	17.1	15.0	12.2	7.3
18	39.8	36.0	32.6	27.7	25.5	22.7	19.2	18.4	16.2	14.1	11.6	7.3
20	35.5	32.3	29.0	25.0	22.9	20.0	16.5	16.6	15.0	12.2	11.2	7.2
	Watts per square foot of horizontal surface											
	6.4	5.3	4.3	3.5	3.0	2.5	2.2	1.9	1.7	1.3	1.1	0.7

The quality of the mercury vapor light has been commented on. Accompanying illustrations show interior views of the plant of the Acme Machine Tool Company. The photopraphs were taken at night under the regular light of the Cooper-Hewitt lamps. The one in the assembly section shows the arrangement adapted to the traveling crane.

INDUSTRIAL POWER

The amount of power required for various industries may be determined from data already given in Chapter II. Various phases of the subject have been discussed in connection with

the financial analysis of industrial enterprises, and there remains only the need to comment briefly on forms of power equipment in the light of its adaptation to the physical needs of the enterprise. For a discussion of the equipment in its strictly engineering aspects, the reader is referred to the books, "Engineering of Power Plants," by Fernald and Orrok, (McGraw-Hill Book Company), and "Steam Power Plant Engineering,"

FIG. 8. Acme Machine Company Shop. (Photographed under regular lighting equipment.)

by Gebhart (John Wiley and Sons). There are many other works of standard form pertaining to the design of power plants, both from the central station standpoint and from that of the individual concern.

Giving attention first to machine manufacturing plants, and to other establishments calling for power for the driving of varied lines of tools, such as furniture factories, leather goods, and a host of others, it has become essentially standard practice to use electric motors, applied either to individual machines or to groups of machines. There are several questions to be taken into account in deciding upon the exact distribution of power in these ways. Very large tools, especially if operated intermittently, may best be equipped individually. Other conditions lead to groupings according to various plans. The engineer must have a free hand in laying out the plan which will represent the

maximum of economy under the conditions given him. Such plants, as a rule, employ power only for the actual requirements in the moving of machine members, without special demands for heat in process.

Whether the electric current may best be purchased from a power company or generated through some form of heat engine at the plant, is a question dependent upon the circumstances.

FIG. 9.—Acme Machine Company Shop. (Photographed under regular lighting equipment.)

With the process heat-demands at a minimum, or entirely lacking, as the case may be, there remains as a secondary consideration in this question the matter of heating the building. Whether the preference will tend toward the isolated plant with exhaust steam used for heating, or toward the purchase of current from outside, depends largely on climatic conditions. For northern sections of the country, where the heating year is longer than six months, there is a strong likelihood that this need will exert a determining influence. For other sections of the country the reverse may be true. In certain sections, where oil or gaseous fuel is abundant and the rates for current supplied by central distributing companies are higher than obtain in more favored sections, the internal combustion engine has become a favorite source of power, usually through the medium of the electric generator. This is true especially of industries where the process work in itself evolves heat, as in certain parts of cement mills.

In other portions of such mills the work is of such a nature that a very small amount of artificial heat is necessary. For such conditions the internal combustion engine is a close competitor for even large and well-established central service stations. The chief difficulty here comes from the fact that investments are high for equipment of this class. In spite of this, however, oil engines of the Diesel and semi-Diesel types are finding extended applications in this service.

For the establishment calling for considerable exhaust steam for heating purposes during a large fraction of the year, and possibly for process purposes, the choice of power equipment constitutes a real problem. The older idea, that any sort of steam engine can be used if there is any use whatsoever for exhaust steam, is losing ground in the face of the competition being offered by the extension of the power distribution systems. Old types of engines use steam in such quantities that the handicap during the non-heating months is coming to be too great to be overcome by the use of exhaust for heating at other periods. This condition has tended to bring about the disappearance of the steam engine from industrial plants.

A type of engine which has not received from writers on steam power plant apparatus the consideration which it deserves has come upon the market. This is the una-flow steam engine, built by eight or ten concerns in this country along designs which differ in some respects from the basic type set by Professor Stumpf. When built with the proper valve equipment to control the period of exhaust, and hence the terminal compression pressure, an engine of this type may be operated either condensing or non-condensing. This permits economical operation as a condensing unit during the non-heating season. Whether or not the change from condensing to non-condensing is made for the different seasons, the una-flow engine, when built according to the best designs, has a steam consumption so low that it can be operated non-condensing at all times and continue to deliver power on an economical basis. For such service, all except the smaller sizes should have the auxiliary compression control valve, and also the extended tail rod support. Unless the latter provision is made, the difficulties of piston lubrication become serious.

Special mention of this type of engine is made because few of the standard books on steam power plant design give adequate

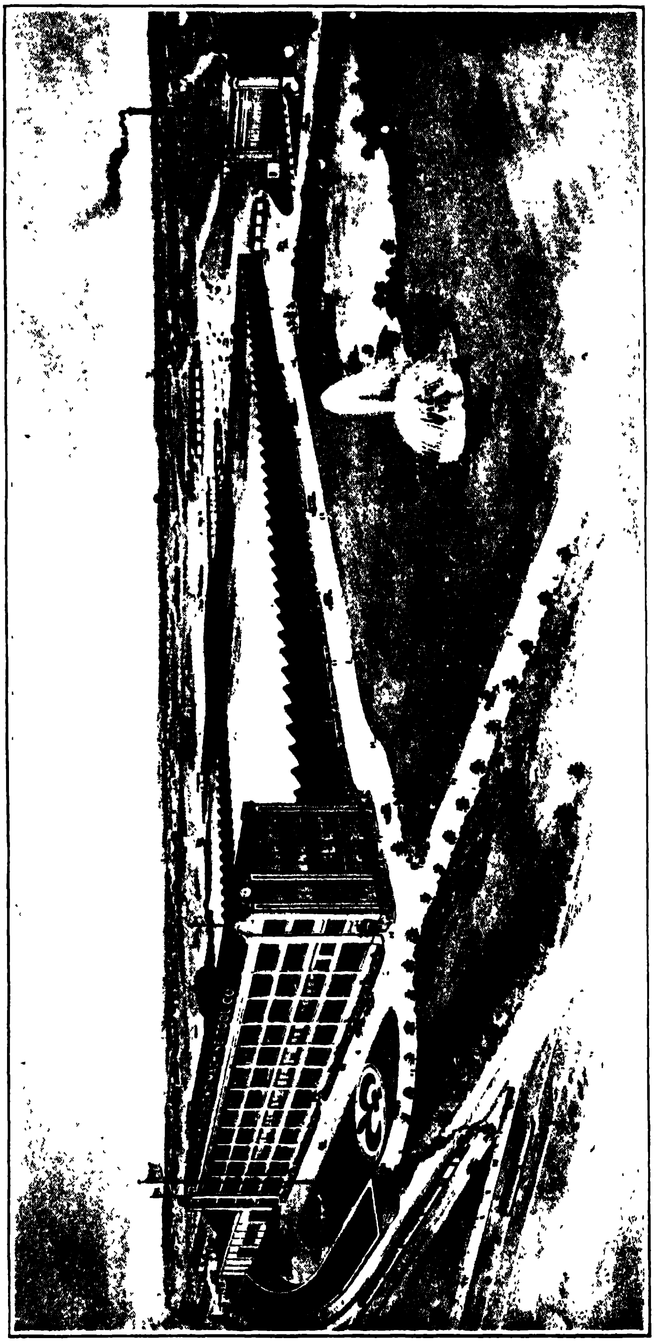


Fig. 10.—Plant of the R. K. Le Blond Machine Tool Company.

treatment. It represents an important step in the perfecting of power equipment for industrial purposes.

The direct application of water power, except through the intermediary avenue of electric current, is now limited to comparatively few types of industries. One of these is the grinding of wood pulp in the larger paper manufacturing plants. Some textile mills and a few flour mills continue to use this method of application. The great influence which the available power from water exerts on the industrial development of various localities rests upon the system whereby electric power is furnished in large amount and transmitted to the point of use.

In general, it may be said that the power element in plant design is one calling for careful study. The industrial engineer may not be an expert in the design of the power plant considered as a unit in itself, but he must be well versed in current practice in its most advanced forms. It is necessary for him to project the design in its general outline, and to go far enough into detail to make the proper allowance for space. Fitting the power plant into the general building scheme is a matter calling for some study. One solution of the question is presented in the accompanying illustration which shows the buildings and grounds of the R. K. Le Blond Machine Tool Company, where the plant is in a separate building. In its detailed treatment, such a plant calls for the same care and consideration that is given to the design of a central station. In other establishments the power requirements are such that it is possible to make satisfactory provision within the process building. Such adjustment is likely to be more economical in investment. One of the primary requisites is to adjust the building plan so that transportation of fuel may be cared for without interfering with the incoming and outgoing movement of process material and product.

THE GENERAL BUILDING SCHEME

Manufacturers are giving more attention in these latter days to the design of the physical plant. There is a growing recognition of two basic factors: one, that in the accurate adaptation of the building to process needs there lies a distinct economic advantage; the other, that those features which contribute to the comfort of workers and appeal favorably to the aesthetic side of human nature, both in interior facilities and exterior surroundings,

serve to make the plant a good place in which to work, and this, in turn, has a distinct economic advantage. It is another expression of the fundamental of industry previously expressed—that industry is a living organism in which the material and the human forces unite. Economic balance will not be attainable except as the whole body is in a healthy condition. The physical plant must be set right in a sane and reasonable manner. With that established on correct lines, management can build its operating structure.

Simplicity, good taste, and sound construction are the recognized tenets of this doctrine. There is being developed in the United States a distinctive type of industrial architecture. Unconsciously perhaps but visibly, plants are taking on a sound and well-kept appearance, with light and comfort as the prominent characteristics. It is not similarity in physical appearance, but a similarity in tone. Perhaps it is the lamp of truth, to use the symbols of Ruskin, that gives expression to the type. The house should tell its own story of what is housed. Industrial plants should proclaim their true purpose. This they can do with credit to architectural judgment, and this they are doing.

A general plan that is comprehensive, adequate for all present needs, and suited to possible extensions in the future must be adopted. This has both exterior and interior elements for consideration. Street lines, railroad lines, available land, points of the compass—all influence decisions as to type of building and plans for future extensions. Whether extension should be made by adding to length or width, or by building entire new units, depends on the same factors and upon character of operating process, as well. Intelligent study is required. To this point the discussion returns on every phase. Study and analysis of each set of conditions is the criterion of correct designing. For this, it is not a set of rules that is needed, but trained minds which have seen visions.

EXERCISES FOR PART I

In the conducting of student class work with this volume as a text, the study of the printed material should be accompanied by exercises calculated to induce thought and train the judgment in making applications to local conditions. Supplementary reading of the numerous references is necessary, especially in collecting data on specific industries. For this, the reports of the U. S. Census are valuable. Local industries in whatever city one may be should be studied. Local conditions may be observed, and students may well devote time to an analysis of transportation facilities, housing for industrial employees, existing power resources, and other factors peculiar to the situation. They should be required to select sites for specified plants and use actual measurements in their design work. The point must be observed that the objective is to design an industry, not merely the plant in its physical aspects.

The following exercises are suggestive only. In each locality the industries to be investigated should be those which are appropriate to the region. Reports should be complete as to form, and made with all the care which would be exercised by the consulting specialist who is preparing material for a company about to engage in a commercial enterprise.

1. Analysis of Development of a Specified Industry.—This is to be a report on the growth in the United States of some industry, treated historically and taking into account the conditions which have led to the locating of plants in the various parts of the country. Among the various influences to be considered are:

a. Markets, in respect to character and extent of demand for the article produced.

b. Geographical position of the market; tendency to shift with population and with commercial developments.

c. Factors which have caused it to become localized, in case it is a localized industry.

There should be extended class discussions and criticisms of the material gathered and of the interpretation of data, following which the report may be given its final form. Industries assigned should be of basic types, such as iron and steel, cotton goods, woolen goods, cement, boots and shoes, flour milling, locomotives, automobiles, agricultural implements.

2. Development of a Market.—The location of the plant will be assumed at the start, presumably at the point where the student happens to be, unless the product is one calling for raw materials which are obtainable only at certain localities. The market will then be designated in its main boundaries and reference made to freight rates, on the product, to primary distributing

points compared with rates to the same points from principal competing plant locations, according to the methods outlined in Chapter III. From this analysis of distributing costs the marketing area accessible to the chosen location of the plant will be definitely established.

The next step will be the preparation of a map of the territory. On this will be shown the leading towns, all railroads which will figure in the distributing plan, and districts where sales will be heavy. This calls for the marking of districts where special efforts are to be made to develop business, such as petroleum fields for the oil well supply trade, if the plant is one manufacturing that class of equipment; agricultural areas especially favorable to the use of a special type of implement or tractor, if that is the line to be built; or some indicating plan to show density of population, if the articles to be made are for general sale. In some cases it will be possible to indicate the origin of materials, or the transportation lines bringing materials to the plant.

In each case the student is in the position of an expert investigator who has studied the territory to determine its needs, its trade customs, the sources from which it has been drawing its supply of the articles under consideration, and its development tendencies. He is to present his report covering matters which will determine the selling policy of the company, in which he will include the following points:

a. Will the articles sell direct to consumers with shipments from the plant in original package, or will it be better to establish distributing houses where stocks will be carried and to which shipments may be made in carload lots?

b. If the latter, shall the company maintain its own branch selling organization, or shall it secure local representatives on a commission basis? In the latter case it must be considered whether the agent is to handle these goods exclusively or in conjunction with products of other companies in lines which will be supplementary to our own, so that he will be in position to offer to customers a more complete line of goods.

c. Shall sales be made direct to the retail trade, and, if so, to what extent should the company coöperate through advertising and the furnishing of special samples and articles put up in convenient lots?

d. Provision to be made for covering new projects in the territory in which there would be a demand for the product. This has special significance when the product is one like brick or cement, used in quantity in construction work.

e. Estimates of the consuming capacity of the territory, and of each of the important divisions thereof.

On the basis of the report there will be prepared an organization plan for the sales department of the company.

Industries that are well adapted to this form of study are farm tractors. tools, pumping machinery, gasoline engines, trunks and miscellaneous leather goods, paper boxes, paper goods, such as ice cream cartons and butter packages, shoes, work clothing, brick and tile, furniture, metal office fixtures and furniture, and machine tools designed for garage supply or other specialty. The list might be extended indefinitely.

3. Analysis of an Industrial Enterprise.—The object is the determination of operating conditions and expenses, including an estimate of the cost of the article produced, for a plant of given size, type, and capitalization. Questions of investment or financial stability are not involved, it being assumed that the enterprise is in normal condition with plenty of capital to insure a proper balance of resources in its stocks, both raw and finished, in relation to producing capacity. Reference is to the discussion in Chapter IV and to the table of the relative values of production factors at the end of Chapter II.

It is well to make this a follow-up of the preceding exercise. Assume that the study of marketing conditions there made has resulted in the establishment of the manufacturing plant, for, we will say, a line of pumps and stationary-type gasoline engines to be used in making up pumping sets for isolated service. Special applications are for irrigation, general farm service, transfer pumping of oil on oil leases, and small-town water supply. It may be assumed, also, that the pumps are adapted for driving by electric motors when current is available, and also that some engines will be built for service other than for connection with the pumps. This makes the product flexible with plenty of opportunity for variations of types to adapt to changing market conditions.

It is a medium-grade product, in the class of general "foundry and machine shop products." The illustrative exercises at the end of Chapter II serve to indicate the use of the table values in adjusting to present-day wage scales. A total investment of $400,000 will be used, this covering plant complete, materials and finished goods on hand, and working capital. After finding the probable value of product from the table, the student may estimate the weight of product handled by taking an approximate selling price of 22 cts. per pound. This is done merely to give a guide in visualizing the plant activities, especially in calculating the cost of materials. The final result of the cost calculations is to be used in checking back on this value of product. The unit costs of materials—pig iron, bar steel, forgings, etc.—will be found from current market reports. The weight of the pumps and engines per unit of capacity may be estimated from catalogs or calculated from designs, literature to serve as guides in this work being available in most technical libraries, or obtainable from manufacturers on request.

The analysis is to be detailed to show items of materials, productive and non-productive labor, factory and general overhead, sales expense, maintenance and repairs, depreciation, insurance and taxes, and investment charges.

Any of the other products mentioned in Exercise 2 may be treated in corresponding manner.

4. Analysis of Cement Mill.—In Chapter IV there is given a discussion of the process of manufacturing portland cement, and a financial analysis of a 2,500-bbl. mill. The student is now required to duplicate this analysis for a mill of capacity of 4,000 bbls. per day.

The first step is to make a sketch drawing, approximately to scale, of the mill for which the data are given in Chapter IV, showing the buildings and major items of equipment. From this he may then proceed to enlarge the plant, and so arrive at a basis for estimating the buildings and other main

items of cost. He may properly assume a proportionately large bond issue in the financing plan, in order to calculate fixed charges.

In the calculation of operating costs, certain items, like fuel and power, will vary in proportion to capacity. Others will vary according to a lesser ratio. Labor and salaries of officials, especially, will increase slowly. Sales expense will be but little larger than for the smaller plant. Miscellaneous items may be assumed as about 50% greater.

5. Design of Manufacturing Plant.[2] In this exercise the student is to put into concrete form for some selected industry the principles which have been treated in Chapter V. This enterprise, it is to be assumed, has been fully studied as to market and location, and also financed. There remains to be carried out only the design of the plant itself, which task is of supreme importance in its effect upon the ultimate success of the company. For manifest reasons it is usually desirable to take a machine manufacturing plant.

The work consists in making a complete study of the selected article, analyzing the process steps in manufacture. Each process is considered with respect to character of operation, the type of tool required for the work, and the time required. The tool equipment is thus determined and selections made. Space requirements in the plant are then fixed, and the arrangement of the space worked out on a general floor plan drawing with a complete study of the routing of material. These steps have been discussed in the text, and will be followed in full detail. Transportation into and out of the plant, storage requirements, power and lighting systems, administrative offices, and all service demands will be given adequate consideration.

After this is done, treatment in as complete manner as is possible in the available time is to be given to the building construction plans. This, again, is to be in accordance with the discussion given in the text, on which there is no need for additional comment here.

The scale of operations, in order that the plant may be of a size justifying the care in design that is contemplated, is to be fixed on the basis of turning out not less than $400,000 worth of work annually. This may mean a tonnage output of 800 tons, more or less according to the character of the machine to be built.

PART II

ORGANIZATION AND ADMINISTRATION

CHAPTER VI

PRODUCTION PRINCIPLES

In the several chapters of Part I, the process of analysis has been traced, through which the physical characteristics of a proposed industry may be established. In that work little, if any, attention has been given to the human factors, except as progress in plant design has taken cognizance of the necessities arising from the housing of workers. Attention has been centered on the development of markets and of materials, in relation to their influence on the location of enterprises, but in all other respects the matter has dealt specifically with the physical requirements of the work to be done in the shaping of material, and with the plants that should accommodate those operations. In the very brief treatment given to the historical development of industries in this country, only the bare facts have been considered. The influence of transportation and the needs of communities were mentioned only in an objective way, in their relation to the growth which took place during the early years.

The purpose of Part I has been to outline the process of industrial design. Distinction is made between the design of an industry and the design of an industrial plant. Stress had been laid on the former. An industry begins with the consideration of the place which the product is to assume as an article of commerce. To produce ever so ably, accomplishes nothing unless there is a market demand. The successful producer knows his market and its needs, and, furthermore, is able to estimate the development of demand. The engineer who would design, or conduct investigations preliminary to the establishment of an enterprise, must be able to analyze a prospective market and plan the form of selling campaign which will develop it. These matters have been discussed in detail in the early chapters of the book.

Following this consideration of the characteristics of product in respect to their meeting the demands of prospective purchasers, there have been considered in order the various physical factors which determine the method of manufacture; locations which

meet satisfactorily the requirements of manufacturing and transportation; the detailed analysis of the article to be produced, for the purpose of determining the character of equipment and of service that will be required in the manufacturing process; and, finally, the design of the plant as a physical structure to accommodate in an effective manner the varied equipment and personnel to be employed in the process work. Some of these questions have touched in a remote way upon the human problems of the industry, but in the main they have had to do with the impersonal contacts of the market and the physical forces of production. The orderly treatment of these elements which enter into the design problem is the significant feature of the work as a whole.

Industry today is demanding a careful and scientific scrutiny of methods of production. It is the dominating characteristic of the present, and will be so in even more definite manner in the future. It calls for the application of sound analytical methods to the solution of production problems. Many of the industrial failures of the past are traceable directly to an insufficient study of markets and methods of reaching them. Many others have been due to unsound methods of finance and insufficient capital. Future industrial engineering practice will be characterized by its consistent attention to these matters, and to the development of proper methods for comparative study.

Systematic design along these lines is the basis for operating efficiency. This is the same as saying that it is the basis on which low production costs may be achieved. It is upon lowered production costs that future industrial progress depends. Unless the United States wins in its struggle to produce goods at a cost low enough to overcome the handicap of transportation expense, the markets of the world will be closed against it and growth limited to domestic needs.

The treatment in Part I covers only that portion of the field which relates to the physical process and plant. The next step to be taken is that of establishing the relationship of the proposed activity to other business interests with which it must operate. The company must be on a settled legal status, organized for the purpose of meeting its external obligations in an orderly and proper manner. There are various alternative plans for accomplishing this, and a judicious selection of methods to be followed, as well as of the exact legal form to give the company, must be made.

The company must be in proper relations with the banking interests. This means that its securities, and paper of all forms, must be properly placed, and in amounts which bear sane quantitative relation to the existing physical property which measures the primary investment in the enterprise. These are not questions of haphazard judgment, but ones which are to be settled on the basis of conservative financial policies and in accordance with well-established principles which are fundamental in the banking business. It is on the correct solution of these questions that the credit strength of the enterprise will rest, on which it may be said that the final success of the enterprise depends.

It must have an operating plan for the conduct of business with outside parties. There must be adequate provision for dealing with those who supply material, with those who purchase the product, and with those who furnish transportation facilities. These and kindred activities involved in the conduct of business must be recognized in the operating organization.

There must be a proper internal operating plan for the conduct of producing activities. In the past, this has been a neglected item, but it has now come to be recognized as something on which the ultimate success of the enterprise will depend. In part, it is a matter of organization, through which there may be realized the necessary coördination of effort. In part, it is a matter of internal administrative policy, uppermost in which is the ever present question of industrial relations between employer and employee.

These and many other items in the conduct of operating plants make up the sum total of administration. Primarily, they have to do with the various human elements which dominate industry. They have points of contact with governmental and financial agencies. Physical, financial, legal, and human factors are involved in the administration of any enterprise. It is on the correct handling of these factors that the success of any industrial enterprise depends. Part I had to do primarily with the analysis of the physical factors. Part II is to be devoted to an examination of the other three.

INDUSTRIAL FORCES

When we begin to study the problems of organization and administration of enterprises, we find in operation a set of forces

different from those dealt with in Part I. The human element begins to tell more largely, not alone as to the complicated relations which may exist between employer and employee, and which must be considered in the adjustment of management details, but also in respect to the motives and ideals which have influenced the builders of industry in establishing its lines of development. We say now that some industries should be located with reference to the market, accepting the present distribution of population as an established fact. The time was, however, when these marketing centers did not exist, and some other set of influences determined the development that resulted in the present distribution of population. Some of the influences were impersonal, such as the location of natural deposits of fuel and ores, the existence of forests and streams, but the ideas and ambitions in the minds of the projectors of enterprises were effective at many points in setting in motion the current of events which determined the industrial progress of cities and even entire states. Many an establishment, and even entire industries, are in their present locations because of such personal motives. It is easy to imagine a distribution of industry in this country quite different from that which now exists, on the basis of different human motives. While certain major characteristics would be bound to exert the influence which they have exerted, whatever the personal desires of organizers might have been, the personal element produced definite results in many instances.

For many years the industrial activities of this country were concentrated on the development of natural resources. The lands of the West were being opened up and the food-producing power was far in excess of the demands of the population. Foreign trade in these surplus products of the farm, as well as of the forests and mines, became an important element in commercial transactions. It became a settled doctrine that raw materials should make up the bulk of export commodities. Tariff measures were enacted in accordance with this plan, coupled with the idea of a tariff to protect the growing manufacturing industries. It may be a strong statement to make, but this conception of international trade had the result of wasting the great natural resources of the nation, and of leaving for the coming generations the serious task of remodeling an industrial system. Perhaps it was inevitable that it should be so, but in retrospect it seems regrettable that the early promoters should have skimmed the

cream, and that industry must now contend for existence on a different competitive basis.

Under those earlier conditions, industrial centers and our great railroad transportation systems were established. Every effort had to be made to move bulk commodities of low value over long distances to seaports, as well as to the great centers of population which grew up in accordance with this commercial policy. It was to the interest of the transportation industries to have return freight, which could be only in the form of manufactured goods destined for consumption at the point of origin of the raw material. Long-haul shipments of both raw material and finished goods thus became the distinguishing feature of the industrial system. While the cream was thick and ready for the skimmer, centralization of manufacturing industries, as well as the segregation of the agricultural producing activities in the West, was the order of the day. Apparently, no account was taken of the inevitable consequence to follow from such practice; results in the form of great centers of population, wherein crowded workers breathed an infested atmosphere of false industrial doctrine, and where the cost of living was bound to rise by reason of the long-distance transportation of food supplies. While this development has gone on, the demands for transportation have been growing. The records of several decades show the transportation demand of the United States to be increasing approximately as the 2.8 power of the population. If continued, this will produce a situation that is unbearable.

While we look at the foregoing statement, which presents merely certain obvious facts, we must consider the influences which were being exerted from the promoters' side. The real industrial development of the country had its beginning in the era of railroad building following the Civil War. For nearly half a century industrial progress was controlled in large measure by a group of moneyed interests in New York. Not alone the railroads, but the manufacturing industry in all of its major lines, came under the direct influence of these interests. Companies were organized or destroyed during pleasant luncheon conversations, at the nod of this or that influential banker or capitalist. Credit, that all-powerful instrument for the determination of success or failure of business enterprise, was granted or taken away as this or that personal interest might dictate. Very much of this manipulation of industrial interests was perfectly honest

and aboveboard. This treatise is not one in which the innate honesty of men is discussed, but the point is that it was under such conditions that the trend of industrial development in the United States was determined. Many phases of this development, while perfectly sound from the standpoint of the then existing conditions, were quite at variance with the plan which would have been followed had there been a clearer vision of what the future would bring forth.

Following that period of intensive capitalistic planning, came the passage of laws regulating the methods of the great insurance companies, saner banking laws, which curbed the operations of various trust companies, and, finally, the Federal Reserve Bank Act, which took away from New York the control of the credit of the country. With this has come the possibility for a more consistent consideration of the ultimate economic needs of the country, and the methods of meeting those needs through a plan of development that is in closer harmony with natural economic tendencies.

Coincidently with the decline of the money power in the metropolis, the producing capacity of the nation has reached a new balance with both domestic and foreign demand. Gradually, the exports of raw wheat, cotton, and lumber have diminished, both absolutely and in relation to the domestic demand. In wheat and lumber the cream has been skimmed. Other nations, blessed with great producing powers, and perhaps suffering under their own unwise local policy of reaping the ready harvest, are meeting the producers in this country in the open markets of the world. The wheat produced by the Argentine farmer is 5 or 6 cts. per bushel nearer Liverpool than is that produced by the Kansas farmer. A different set of conditions in respect to our export trade calls for different treatment.

Under the impulse of the World War the United States became a great manufacturing nation. The export trade for manufactured articles stimulated industry until the potential producing power of the mills and shops far exceeded the demands of the normal domestic trade. In the years following the close of the war, a process of readjustment has been going on. The potential producing capacity still demands a large export trade. To gain in the foreign market, and to hold the market acquired during the period of disturbance, have demanded economic production. In many lines of manufacturing in this country, the export trade

has amounted to from 10 to 20% of the total product. Prosperity not only in these but in many related industries demands that the foreign trade be maintained, which demand can be expressed in corresponding terms of low production costs.

With these conditions before us, it is realized that the methods and personal motives which guided the actions of the dominating personalities in New York during the great developing period led to different results from those which would follow from a correct application of conditions of today. A problem of twofold proportions confronts the manufacturing interests of the country. The normal demands of the present competitive system which exists in the markets of the world must be met, and at the same time the mistakes of the past must be corrected. This has its parallel in the fact that managers of industries must not alone meet the problems of labor in their bearing upon normal production under present-day conditions, but there must also be corrected the mistakes of past years, out of which has developed the bitterness of internecine strife. The producer today must not only meet the conditions of high transportation cost arising naturally from the long-distance transportation of many commodities, but must also overcome the handicap of the system which involves unnecessary transportation resulting from a development of the past under a prejudiced régime. In all lines there is the demand for construction and reconstruction along intelligent lines. It is a situation that calls for careful planning and for the best brains which the country affords.

THE MAJOR PROBLEM

In order to avoid the charge of appearing to take the ground that all methods of the past are wrong and that revolutionary practices must be instituted, let it be said that people learn from past experience and that changes in the realm of industry come gradually. It is for the purpose of emphasizing the ultimate aim that the foregoing discussion has been directed in such manner that it indicates a radical departure. No such radical change is possible or even to be contemplated. It is sometimes desirable, however, to paint in contrasting colors for the purpose of bringing into clear view the major motive. In the field of industrial development this major motive is systematic planning, based on an analysis of all the elements which enter into the

situation. In this, the emphasis is on the taking of all factors into account. Too much of the so-called scientific planning for the improvement of operating conditions, which has been carried on during the last two decades, has been based on a consideration of only a portion of the facts. The time has come when all facts must be taken into account, both material and human.

Administration must concern itself with the elimination of avoidable wastes in industry. It may be said that the elimination of waste is the center and substance of the new thought in industrial economic lines. The captains of industry who determined the character of enterprises during the great development period were following a line which eliminated one kind of waste, even though they created other forms. Transportation in that earlier period made concentration at the seaboard points economical. But with the extended network of railroad lines created by these same developing geniuses, there was created a condition which made decentralization a means for saving wastes in many lines of enterprise. This is what is meant when we say that those organizers developed the conditions which produced sources of waste at the same time that they were working for effective operation.

The wastes of transportation are too numerous to mention. It has already been noted that the demand for freight traffic is excessive. Our centers of population are too far removed from the centers of production of foodstuffs and other commodities, and there is waste in the actual carrying on of transportation. Concentration of industry has led to congestion in the crowded terminals, until it has come to the point in some cities that transportation facilities are not adequate to take care of the product of mills and factories, should all of the latter be producing to full capacity at the same time. Through traffic, which never should enter these congested points, is jamming the terminals in many of these cities. This represents waste, produced in part by a policy in railroad development which was correct enough for business as it existed during the active railroad building period, but which is wrong as viewed in the light of developments which have taken place since that era. The discussion in this volume bears on this question of transportation only as it may have to do with the question of the location of industrial enterprises. The opportunity is taken at this point to call attention merely to the existence of the wastes involved in the

carrying on of the great transportation industry of the country. It is a condition which must be remedied by intelligent action. One manifestation of it is its call for decentralization of industry.

Another waste, already mentioned, lies in the fact that our centers of population are too far removed from the source of food supply. Expressed in terms which have a bearing on the question of the planning of industries, this means that industrial development on a significant scale in each of many hundreds of smaller towns scattered throughout the country would have the result of building up home markets which would react in favor of both the manufacturing and the agricultural interests. Long-distance transportation places a handicap on the farmer who is devoting his energies to the growing of specialized crops, such as wheat. Bring the people into medium-sized towns nearer the source of food, and there is created a stimulus for diversification of crops, and a prospect of better food for the consumers and better prices for the producer. This problem of adjusting the food supply to the needs of people is given more attention at the present day than it received a few decades ago. Insofar as reduced production cost of manufactured articles is related to a lowered wage scale, the cost of living is a matter of first significance, and the cost of food is paramount. Whereas, in the past this question of food supply and its effect on the cost of living has been considered purely as a resultant of other economic forces, the time is near at hand when it will become one of the primary considerations. Already many companies are looking about for an opportunity to move from congested centers into smaller communities, where the problems of living and the social atmosphere are more favorable to the maintenance of an effecitve working organization.

There are wastes incident to the character of product. In many lines of activity, unnecessary labor is being performed, with consequent increase in cost, because of unnecessary variations in types. Granting that the marketing of certain articles is facilitated by making them in a manner that will attract trade, there exist, nevertheless, possibilities of simplication and standardization. A notable instance which illustrates this point was afforded at a meeting of paving brick manufacturers a few years ago, at which an agreement was reached to reduce the number of styles of brick to about one-fourth of the number which had

previously been on the market. Such a result produces no injurious effects upon the workers producing the article, since it is no more fatiguing, or mind-wearying, to produce one style of brick than to produce another. What was true in this instance would be true in many others, in varying degree. Standardization of products is decried in certain places. Sometimes the contention may be sustained that workers are subjected to monotonous tasks and that the results gained are not commensurate with the human losses. In many other instances this contention is of no significance. The conclusion here is exactly the same as that expressed at other points, namely, that all of the facts which bear upon the case must be taken into account in order that the correct results may be arrived at. Sound analysis on a basis such as this never fails to produce the correct result.

There are wastes incident to process. This is so patent a fact that comment is unnecessary at this place. The methods of process analysis outlined in Chapter V indicate the line of study which is necessary in solving the physical questions involved. Here, again, criticism is encountered from those who see, in the standardization of methods of work, the possibility of injury to the worker. One answer is to be given to this criticism. If the method adopted for carrying on of the process step is one which results in undesirable conditions for the worker, and a competent and unbiased study of the situation shows that the loss sustained is of material significance, then the method is not the correct one. It is necessary to repeat again and again the statement that no system of analysis is scientifically correct if it fails to take into account all the facts which bear upon the situation. The human element is one of these facts and must be given its proper share of attention. In general, it may be stated that, in American industries, practice has reached a much more advanced stage in matters of process and equipment than in respect to the human agencies. Management has lagged behind, and only recently has it assumed the position of importance which it deserves in the eyes of the administrator.

There are wastes incident to equipment. While it is true that the past generation has witnessed marked improvement in working equipment and all of the attendant machinery employed in the application of mechanical energy to industrial processes, there is still room for further improvement. This is closely related to the problem of utilization of equipment through effec-

tive management sytems. There are some phases of the question which relate solely to equipment, however, particularly in respect to power economies. Ever present is the question of generating power in the private plant, where auxiliary service may warrant it on the one hand, or purchasing power in the form of electrical energy on the other. In the past generation, fuel cost as compared to labor cost was less than that which now obtains. Coal was relatively cheap and labor high in this country, as a result of which great strides were made in perfecting labor-saving equipment with less attention to fuel economy. At the present time the high relative price of fuel is changing the point of emphasis, or, at least, is bringing again to the minds of industrial managers the importance of the power element in manufacturing. The saving to be accomplished here in the manufacturing industries may not be great. In other fields, notably in railroad transportation, the prospect of fuel economies constitutes an alluring opportunity for the man who is inclined to enter upon the study with care and skill. It is a safe prediction that a material reduction in the total fuel needs of the country would be possible if all the industrial activities of the country were to realize in full measure the economies that are attainable through well-established steam boiler practice. Still further reductions will be achieved as the railroads become able to equip according to the best of modern ideas.

There are wastes, the most alarming of all, through failure to realize in full measure the returns of human effort. It is in this line that industrial management of the past has made its most conspicuous failures. Only in recent years has serious study been given to methods calculated to make labor effective. This is a subject so sweeping that an entire chapter is to be given to the discussion of personnel administration. It is a fruitful field for anyone seeking opportunity to exercise his executive abilities. The entire question of industrial administration centers around it.

PLAN OF TREATMENT

In summary, administrative functions in the industrial field are to be considered under two general headings:

Determination of policies in external relations.

Executive control in internal management problems.

Under the first come all of the questions regarding company formation: conditions of its chartering for the fixing of its legal status; financing; and the control of major activities involving making of contracts, and associations with other organized companies. Under the second come all of the questions pertaining to operating procedure, including organization types and division of managerial responsibilities. In the succeeding chapters these matters are dealt with, approximately in the order which would be followed in the formation and organization of an enterprise.

The plan of the book is thus made to conform to the order of events which would be followed in the establishment of an industry. Part I covers the study of the character of the product in relation to market demands and conditions; the choosing of a location; the making of preliminary estimates of the cost of production; and the fixing of the physical characteristics of the industry with respect to product, equipment, and plant layout. In Part II the work is continued under the general headings of the formation and chartering of the company; financing; determining the type of internal organization; and the basic elements of personnel administration. Appended to the primary discussion, is a brief treatment of cost accounting from the standpoint of the keeper of shop cost accounts, and the elements of the law of contracts. These latter are but brief discussions, made up in considerable part of quotations from standard authorities. The reason for including them is to enable students using the volume as a text to gain an understanding of the simpler elements of these subjects, which are of importance in the conduct of engineering work.

CHAPTER VII

ORGANIZING THE COMPANY

Business organizations, industrial and otherwise, are commonly classified under three heads according to ownership. By "ownership" we mean the control of the property itself and of the regular outstanding stock considered as evidences of the property. These three types are:

Individual ownership.
The partnership.
The corporation.

It is now to be assumed that the industrial enterprise under consideration has been carried through the several stages of design, as outlined in Part I. The person (or group of persons) interested in its development has carried the proposition to the point where he has in mind a definite picture of the enterprise and reliable estimates of the cost of construction and of installation of all the equipment for carrying on the business. He has selected a location for the plant, the market area in which he will extend his business, and is now able to visualize the entire program to be undertaken. It may be that he has in his possession, or readily accessible, all the funds necessary to proceed with the construction of the plant. On the other hand, he may have immediately available only a comparative small portion of the amount necessary to put the plant on an operating basis, and it will be necessary to determine some method for securing the necessary funds.

If he is in the condition of having at hand all the money that is necessary, he may proceed on a basis of individual ownership. In this status he would exercise simply the right of the individual citizen of the country to carry on business, which includes the right to make contracts of any and all kinds, own land and other forms of real property, and to proceed in the carrying out of any sort of business program permissible under the general laws of the country. Individually owned establishments are generally small, however, and most persons are inclined to hesitate at the

prospect of having their entire personal property tied up in a single enterprise, or at least held in a status such that it could be attached through legal process for any liabilities which might be incurred. In view of this situation, this class of company organization will be dismissed from mind and attention centered on the other forms.

When one turns to a consideration of the different types of company organization, for the purpose of fixing upon the one which will effectively serve the purpose at hand, he must bear in mind the significance of the steps which are to be taken. It is through business organization that the forces of industry are made effective. It has been made apparent already that the forces of industry are many in number and varied in character. In order that everyone may be utilized to the fullest advantage, and the enterprise proceed on an efficient basis, care must be taken to select the form of organization which will permit these forces to function with the least friction. Into the question come the various degrees of the personal financial responsibility of those who invest money in the enterprise, and the necessity of having sources of capital adequate to insure a margin to meet not only the ordinary demands but also the unusual vicissitudes which arise. Measures must be taken to inspire confidence in the undertaking in the minds of all persons who will be encountered in the ordinary routine of business. The success of an enterprise of this character—and this is essentially true of all industrial plants—depends upon confidence or credit. Under the customs of modern business, credit is the key to success. Nothing should be spared that will tend in any way to increase the confidence of the business public. Everything must be avoided which tends in any way to throw doubt or question on the motives of the organizer or the financial background of the new company.

At this stage in the process of company formation the greatest of care must be exercised in the forming of attachments. If several different individuals are to share in the investment, these same individuals must share in the exercise of control. The investment of money in an enterprise means the assumption of a degree of responsibility for the conduct of affairs, the extent of this responsibility varying with the form of organization. With this responsibility there must go the corresponding measure of authority. This is the foundation principle in all organizations,

whether reference is had to organizations for the handling of external relationships or for internal executive control. Authority and responsibility must go hand in hand. At this juncture, therefore, care must be taken to measure the extent to which different individuals are desired as participants in the control of the company. Invitations to these individuals to make investments must be made proportionately. Failure to observe the necessity for establishing correct balance at this point has been responsible for many misunderstandings, often leading to friction and ultimate reorganization.

Banking interests may figure heavily in the making of decisions. A bank may have agreed to make loans, or to buy bonds, which in reality, constitute a loan, the doing of which would not normally give the bank any voice in the control of the enterprise. As a means for securing this financial backing, however, the company may find it necessary to give the bank a voice, or to take some individual named by the bank into its directing group. Positions on boards of directors are thus frequently bestowed upon individuals who may have little personal financial interest, but who are there for the purpose of protecting the financial interests of heavy investors. When industrial enterprises and the control of credit were so largely in the hands of the moneyed interests in New York, certain men held places as directors in many enterprises. With credit so largely under the control of central institutions, it was necessary that this be the case in order that interests should be safeguarded. The result of this was the tendency toward large organization, in order to keep the number of boards of directors as small as possible. With the greater freedom in the extension of credit which has come about since the passage of the Federal Reserve Bank Act, credit flows more freely and the formation of comparative small enterprises may proceed with less difficulty.

This leads to a consideration of the desirable magnitude of individual corporate interests. The aim is to secure an effective utilization of the forces of industry. The question arises, then, whether the large concern has manifest advantages over small ones. The record of notable industries has shown in past years a tendency to increase the holdings and the extent of influence of central boards of directors, especially during the latter portion of the period referred to above. The time has come, however, when manufacturing industries have found that, beyond a

certain point, increase in size does not mean increase in effectiveness. The process of decentralization has actually begun in a few instances. After growth has proceeded to this critical point, advancement is made through the establishment of branch plants, each under separate administrative control. It may be said that this does not apply directly to the question at issue, since the corporation with its many branches has its one central board of direction. As a tendency in industry, however, it does bear on the main question. New organizations should so direct their initial proceedings that alliances will not be formed which might later become embarrassing should marked successes lead to greatly increased size.

The actual investments made by those who are ready to stake the enterprise must be sufficient to form the basis for future loans which will be necessary to complete the plant. This is really the first step in the building up of company credit. If the concern owns its land and a goodly portion of the fixed property, in the form of buildings and major types of equipment, the investing public will be inclined, other things being favorable, to repose trust in the enterprise. Whether it be a partnership or corporation, the amounts of the original subscriptions must, therefore, be carefully considered in comparison with the total amounts that will be required. These comments pertain in considerable measure to financial policy, which is to be developed in greater measure in a succeeding chapter, but the question is an important one at this stage when conditions influencing the form of organization are being carefully considered, and the motives of those on whose acts the future credit and success of the undertaking will depend are being revealed.

At this stage in the development it is necessary to consider two other questions which will later become vital as policy measures. One of these has to do with the attitude of the general public toward the enterprise. The other one is the policy which the management is to adopt in its relations to employees. As an enterprise, it is, in a measure, engaged in public service. A successful company is an asset to its community. This principle is basic in the enactment of laws controlling the corporation, wherein it is distinctly recognized that there is a contractual basis to the agreement between the concern and the state, and that in this contract the service rendered to the public is the consideration offered by the company in return for which the state allows

certain privileges. This must be kept in mind as a fundamental element in corporate business. At one time the public was inclined to view all corporations in a more or less suspicious manner, this tendency growing out of abuses which grew up in the latter part of the nineteenth century. This tendency has abated largely, due, in the main, to the greatly increased number of people who have become stockholders in corporations. Widely distributed ownership of industrial enterprise is an effective means for acquainting people with practices and motives in business. It has much to do with the clearing up of prejudices. With this development in the understanding of corporations, with which has come a growth of the idea that a corporation is a form of enterprise in which the public is an interested party, it is natural that people should come to look upon the partnership with some suspicion because of the exclusiveness of the control there exercised by a small number of heavy investors. These suggestions do not indicate the existence of a strong impelling influence, but rather of a tendency in public sentiment which should not be overlooked by those who are deciding on the question of the type of organization to be adopted.

In anticipating the policy to be followed in establishing coöperative relationships with employees, it should be borne in mind that the extension of ownership through the selling of company stock to the workers is an important consideration. If such policy is anticipated, then care should be taken to insure a type of organization, and the provision for stock classification in small denominations, that will make possible this plan of procedure. There may be other elements and other methods of dealing with the question of industrial relations which need also to be taken into consideration. Enough has been said to indicate the necessity of giving most careful attention to the many agencies, public and individual, which may at some time in the future have an influence on the undertaking, either for or against the enterprise. As further guidance to the consideration of these questions, the following pages of this chapter deal in considerable detail with the more important characteristics of the partnership and the corporation.

The practices of different states are given because the company organizer must take into account the section of the country in which he expects to do business. It may be the best plan to incorporate in the state in which the principal plant is to be

located. With the growth of the company, however, plants may be established in other states, so that the significance of the state of original location is diminished. Markets will extend usually over many states, so there is no real occasion to consider the case from a marketing standpoint. The advantages and disadvantages coming from incorporating in the different states are indicated clearly in the discussion.

The following figures furnish an interesting commentary on current practice in the United States in respect to the ownership of industrial enterprises. As given by the U. S. Census reports, organized manufacturing companies are divided among the three forms as follows:

Form of Ownership	1899	1904	1909	1919
Individual ownership	171,832	113,946	140,605	(.....)
Partnerships	62,613	47,934	54,265	(.....)
Corporations	37,123	51,097	69,501	(. . .)

The distinctive feature in this is the trend toward the corporation form. Corresponding to this is the tendency toward large establishments, which is, in itself, a significant explanation of the popularity of the corporation. In 1909 the corporate-owned plants employed 75.6% of all wage earners engaged in industry. As before noted, modern conditions make necessary large accumulations of capital for the successful prosecution of producing businesses on an economical basis, and the corporation makes this possible in ways that will be explained.

PARTNERSHIPS

A partnership rests on a purely contract relation, expressed or implied, existing among the persons comprising it. It may be defined (Tucker) as "the relation existing between persons who have agreed to combine their property, labor, skill, or some or any of them, in lawful commerce or business, sharing the profits, and generally the losses, between them." The statement is simple, but a knowledge of contract principles is necessary for its understanding.

It is obvious that all contract essentials must be complied with. This means that only legally competent parties may enter into partnerships; that the business undertaken must be of a lawful nature; that each party must contribute something of value as a legal consideration; and that the intent and purpose of the parties to enter such a relationship shall be clearly shown, either by

written agreement or such specific acts as would give complete evidence that each party did so intend and purpose. It follows that on certain occasions the partnership contract must be construed according to usual procedure in the construing of civil contracts.

When written, the instrument is called the "partnership articles." In framing it the following topics are usually treated, but with the understanding that in the interpretation that would be rendered in case of disagreement among the partners there are many other points and various principles that would be given consideration under the common law. One such point is that if the business of the firm continues beyond the period of years mentioned in the articles, but without written agreement modifying the terms, the original terms will govern during the extended period. These topics are:

The general nature of the business.

Date when effective and the duration of the partnership.

The firm name.

The capital or other valuable consideration supplied by each partner.

The rights and duties of each partner and the basis for division of profits.

Provisions for periodic accounting of resources, profits, etc., and basis for final accounting on dissolution, or on retirement of any partner.

Restraint upon partners from transacting business in competition with the firm.

Any special agreement whereby any partner's liability is to be limited or he is to hold any special connection.

Any other matter of significance peculiar to the business.

It is not the purpose to discuss legal phases of partnerships. In what follows the aim is to present certain important facts that everyone should understand, with the particular aim to bring the essential differences between the partnership and the corporation into relief. Such understanding is necessary on the part of one who is deciding upon the form of company to be selected as most suitable for any contemplated enterprise.[1]

[1] The reader is referred to standard works for the fuller treatment of the subject, among which the following will be found useful:

TUCKER'S "Contracts in Engineering," chap. VI (McGraw-Hill).

CONYNGTON'S "Business Law," (Ronald).

BRISCO'S "Economics of Business."

There may be different kinds of partners, distinguished as to powers in the firm and liability for firm debts. Special partners, as the term is commonly used, have their liability for debts limited to specified amounts. A silent partner is one who has no voice in the management, although he may have all other rights and be subject to all duties. A secret partner is one whose connection with the firm is not announced, but who may be declared liable for debts if creditors discover his relationship. The term "general partner" is sometimes used to designate such as hold the standard normal relationship to the business, with full powers and liabilities. It is to this last type that all statements that follow apply.

Each partner in the usual organization is a fully accredited agent having power to transact business in the name of the firm. Under the rules of agency he by his acts, binds the firm, provided he acts within the range of authority set by the nature of the business for which the company was organized. Since the relation of agency is here an implied one, the customary rules for construing implied contracts as well as the usual rules of agency govern.

The holding of real property is on a joint basis, in which the partners must act together, all signing deeds at transfer. This principle sets a limit on the authority of a partner as agent, in that he cannot make a firm assignment, nor a mortgage, deed, or lease of realty. This constitutes an important distinction between the partnership and the corporation.

Partners are, in general, jointly and severally liable for all debts of the firm. This is the most significant element in partnership, when the question at issue is the selection of the form of company organization best adapted to an enterprise. It constitutes a barrier to investment in many cases, since men with large private means will hesitate before entering into a venture in which not alone their direct investment in the business, but their whole property as well, is subject to attachment. Here, again, the corporation offers a marked contrast, in that the liability of investors is limited to the amount of the stock purchases, or, at most, for certain special businesses, like banking, to double the par value of stock holdings.

An important principle that governs in various dealings of a partnership with individuals or other firms, in which arises the question of limitation of liability of any partner whether by

original provision of the partnership articles or by the retiring of a partner from the firm, is the giving of information in a public manner. The interests of parties dealing with a firm are protected in every reasonable way. The firm must cause it to be known, so that the ordinarily prudent and cautious person may become informed, whenever any such special condition exists. Without such policy in the adjustment of disputes, persons dealing in good faith with a firm, with confidence in the financial strength of partners, or supposed partners, would be subjected to possible fraud and sharp practices. The principle follows naturally from the contract essential of mutual agreement. There can be no valid contract when any uncertainty exists as to the identity of parties subscribing thereto. The fixing of a partner's liability is not for the purpose of affording special protection to innocent outsiders, but simply an instance of adjusting matters on the basis of sound business practice in adjudging the validity of contracts.

CORPORATIONS

We come now to the most commonly employed, and hence the most important, type of company organization. Certain limitations have been noted in the two forms already treated, these limitations having to do primarily with the possibilities for making capital available in quantities sufficient to make effective operation possible. Specialization and mass production have been cited as distinguishing marks of modern production methods. These may not be realized unless business is carried on on a large scale. It is in the interest of the public generally that such activities should be fostered, and the corporation is the outcome of legislation calculated to achieve that end. Without it the development of a country would be retarded.

Quoting from Tucker, "A corporation is a collection of individuals united by law under a special name, with the capacity of perpetual succession and of acting in many respects as an individual. It is regarded as a distinct legal entity, existing only in contemplation of law, and by virtue of the operation of statutory law." The idea of its being a distinct legal entity is a fundamental one, establishing several vital points. Thus it is that a corporation has a residence in the state under whose laws it is chartered.

Kinds of Corporations.—Classed as to object, corporations are known as *eleemosynary*, or devoted to charitable purposes; *religious*, which term forms the definition; or *civil*, including all other types. Another distinction is carried in the terms *public* and *private*, the common example of the public being the municipal corporation.

Distinguishing Characteristics.—A corporation is spoken of as a distinct legal entity, having an existence separate from that of its members. This characteristic is of great value in the transaction of business because of the element of permanence thus introduced. It is a thing of real value which is granted by the state in the act of incorporation. In accepting it, incorporators agree to perform some useful function in the promotion of industrial enterprises, or in some other desirable manner, and this mutual transaction or agreement constitutes a contract. Every purchaser of stock subscribes thereby to the agreement made by the incorporators, while at the same time his act of purchase and the acceptance of the stock certificate complete the formation of a contract between him and the company. This contractual relation is well recognized in law, but the states have avoided what might be an embarrassing situation arising from the constitutional restriction that a law impairing existing contracts may not be passed (which would seem to make it impossible for a state to take steps to abolish or modify a corporation once formed), by passing laws to the effect that no charter shall be granted which may not be thus altered or withdrawn. This formation of a contract, attested to by the charter, together with the corresponding agreement between company and stockholder, constitutes the dominating characteristic of the corporation. The charter comes directly from the state, either by special legislative grant or, more commonly, by action of the Secretary of State, or Commissioner of Corporations acting under the authority of legislative action. It must be applied for in writing and accepted by the incorporators.

An attendant requirement is that the purposes for which the company is formed must be fully stated. This is an element in contract writing, since the parties must have a definite understanding of what is being contracted for. The charter serves both as the conveyance of right to exercise corporate powers and as the memorandum of the agreement. In the former capacity it must state the fact of the grant of power and indicate the

usual extent and limitations of those powers. This may be left largely to interpretation under the common law, usually understood to mean that a corporation has the right:

1. To the use of a corporate name.
2. To perpetual succession.
3. To acquire, hold, possess, and dispose of property in its own name.
4. To appoint officers and agents, and to fix its own rules for transaction of its legal business, guidance of officers, etc.
5. To sue in court and be sued.

In the capacity of the charter as a memorandum of agreement it must state the name of the corporation, its object, its principal place of business, usually the amount of its capital stock, number of shares, amount of money paid in at time of incorporation, and sometimes, under state laws, the names of original stockholders.

Formation.– In the process of formation of a corporation, the promoters must execute a paper giving all the information, including a full statement of purposes, and deposit it with the proper state officer. In bona fide business enterprises there is some one specific purpose in view, usually one in which some one active man has a special interest. Most charters are worded to give to the company a wide range of business, although this is carried sometimes to an extreme which is highly undesirable. If one watches the public notices of new corporations formed he will see statements of purposes which empower the company to engage in every form of manufacturing, mining, building, and transportation, with a multitude of intermediate lines of activity. Such variety is undesirable, and it is unnecessary on the score of making expansion possible, since the courts construe liberally in the way of allowing the carrying on of all necessary lines of work tributary to the main purpose. This matter of the implied powers, on the basis of necessity, custom, and usage, is one which receives much attention, and definite rules to cover practically every possible point are in existence. In the matter of promotion expenses, promoters often are held personally responsible by law. Many companies never progress far beyond the grant of a charter, so that unscrupulous persons might run up accounts and then hide behind a lifeless corporation, were it not for such provision.

There are many provisions embodied in the several state laws in their corporation acts that should be understood by all who are concerned with the organization of new companies. There is a certain advantage in being incorporated under the laws of the state in which the business is to be carried on, or in which the principal office is to be located, but sometimes it is of advantage to go to some other state. The differences lie mainly in provisions as to the holding of meetings of stockholders and directors within the state, and in the incorporating fees and annual taxes. Another provision, sometimes mandatory but more frequently permissive only, is that for cumulative voting at stockholders' meetings. This is a matter calling for explanation.

Cumulative Voting.—It is usual practice for stockholders to have voting power in proportion to the amounts of stock held by the individuals—a vote for each share. In the election of directors, where several are to be selected, the holders of a majority of the stock would be able, under the direct voting system, to elect the full board, thus leaving the minority of stockholders unrepresented. How the cumulative system of voting operates is best shown by numerical example, as follows:

Suppose there are 1,000 shares of stock, 550 being held by one group and 450 by the other; also that five directors are to be chosen. Each share of stock has five votes—one for each director. The cumulative plan provides that a shareholder may cast one vote for each director or all five for any one, or divided in any way he chooses between two or more directors. The majority therefore has a total of 2,750 votes and the minority 2,250. If the majority concentrates on three candidates, giving each 916 votes, they will be elected, while the minority can give 1,125 votes to each of two others, electing them. If the majority tries to elect four, giving them each 687 votes, the minority, by concentrating, can elect three by giving them each 750 votes. An organized minority can therefore place on the board a fair representation, even a majority if the majority of stockholders are unorganized or unscrupulous in their attempts to dominate. By assuming different figures to represent the division of shares of stock, the reader can calculate the possibilities for the minority to secure representation on the board for varying conditions.

STATE REGULATIONS

Certain of the states have enacted corporation laws that represent an enlightened and progressive business attitude. Others have laws that are lax, calculated to attract organizers who are looking for an easy way to launch their enterprise and to avoid restrictions by which the more conservative states protect the interests of investors. States with the free and easy laws are referred to as "bargain counter" states. Between the two extremes, are states that differ materially as to fees, however, so that a new concern may properly enough look about for the most favorable charter. The following statement of provisions of the laws of several states shows the advantages and disadvantages, for which statement the author is indebted to Modern Business Series" of the Alexander Hamilton Institute, Volume VIII.

The chief respect in which state laws differ, so far as liberality is concerned, is in granting or denying the right to buy and sell the securities of other corporations. In 1889 New Jersey, first of all the states, enacted that corporations formed under its laws might hold the stock of other corporations. This privilege proved of great importance in the financial and industrial development of this country. The New Jersey act in this respect was followed by Delaware, Maine, and New York. In 1913, however, through the so-called "Seven Sisters Law," New Jersey attempted to define and make illegal and criminal all monopolies and agreements to discriminate, prevent competition, limit production, and fix prices. The great industrial trusts, which formerly patronized this state when incorporating new companies, are now obliged to look elsewhere.

Another feature in which the various states differ widely with regard to liberality is the issuance of stock for property. Most corporations as now organized turn over at least part of their stock in exchange for property, not cash. Some of the states make the estimate placed by the directors upon the value of the property so secured conclusive unless fraud is clearly shown. Other states hedge this general principle about with irritating and usually unnecessary restrictions. Liberality of the state laws as to other less important points will be considered by careful incorporation, but they are too technical to be discussed here.

In those states in which the general corporation statutes have existed for some years practically unchanged, it is reasonable to expect that they are in fairly permanent form. Moreover, in such states the courts have given a large number of decisions on vital points. Both the statutory law and the interpretation of that law, therefore, may be considered well settled. This is a matter of prime importance to large

corporations, which may expect, from the very extent of their business, to be involved in more or less litigation. They want to know where they stand at all times and do not care to be confronted with sudden legislative enactments or with unexpected court decisions. For this reason the large corporations which had incorporated in New Jersey were especially hard hit when the "Seven Sisters Amendments" were suddenly enacted.

The liabilities imposed upon stockholders have already been treated. The states of California, New York, and Minnesota impose certain liabilities additional to the usual liability on capital stock. These liabilities are not apt to prove a serious matter. Yet corporations generally look with some alarm at any provisions of this nature.

For the benefit of readers who may desire to form a corporation or who may have occasion to consider the advisability of buying stock of a company incorporated in some other state than the one in which it does business, we give below a brief summary of the advantages and disadvantages of several states;

Arizona

Advantages:

1. Stock may be issued for money, property, or services. The fact that it can be issued for services may be an important advantage.
2. Directors' meetings may be held outside of the state.
3. The organization fee is very small. The annual franchise tax is small.
4. Cumulative voting is permitted.

Disadvantages:

1. Stockholders' meetings must be held within the state, unless at the first meeting a by-law provision permitting subsequent meetings outside the state is adopted.
2. The corporation laws are not thoroughly adjudicated.

Connecticut

Many promoters do not care to incorporate in Connecticut, as they imagine that the advantages are not great. As a matter of fact, the high organization fee is the chief disadvantage.

Advantages:

1. Stock may be paid for either in cash or property. The judgment of directors is final with regard to the value of the property for which stock is issued, except in case of fraud.
2. Incorporators may be non-resident.
3. There is no annual franchise tax.
4. Corporations may hold stock in other corporations.

Disadvantages:

1. Stockholders' meetings must be held within the state. There is no provision requiring the meetings of the directors to be held within the state, but this may be inferred.
2. There is an inheritance tax on the stock.
3. The organization fees are comparatively high, from $25 to $2,510.

Delaware

Advantages:

1. Stockholders' and directors' meetings may be held outside of the state, if the by-laws so provide.
2. Stock may be issued for cash, property, or services.
3. Incorporators may be non-resident.
4. Corporations may hold stock in other corporations.
5. Provision may be made whereby bondholders will be permitted to vote. This provision makes a good market for bonds, because bondholders will be assured that they will have a voice in the management of the corporation.
6. Organization fees are not very large, ranging from $20 to $765, including filing fees.

Disadvantages:

1. One of the directors must live in Delaware.
2. There is an inheritance tax on stock, applying both to residents and to non-residents.
3. There is an annual franchise tax.

Maine

Advantages:

1. Stock may be issued for property, cash, or services. The judgment of the directors is conclusive as to value of the property, always provided there is no evidence of fraud.
2. Incorporators and directors may be non-resident.
3. Directors' meetings may be held outside of the state.
4. The corporation may acquire stock in other corporations.
5. Low organization fees, ranging from $10 to $517 for a $5,000,000 corporation.

Disadvantages:

1. Stockholders' meetings must be held within the state.
2. There is both an inheritance and an annual franchise tax; the latter, however, is very small

Massachusetts

Advantages:

1. Incorporators and directors may be non-resident.
2. Directors' meetings may be held outside of the state.
3. Stock may be issued for cash, property, or services.

Disadvantages:

1. Stockholders' meetings must be held within the state.
2. It is doubtful whether ordinary corporations can hold stock in other corporations.
3. A detailed annual report must be rendered to the state authorities.
4. There is an inheritance tax.,
5. The organization fee varies from $25 for a $10,000 corporation to $1,200 for a $5,000,000 corporation.

New Jersey

Advantages:

1. Corporations may hold stock in other non-competitive corporations. New Jersey was the first state to authorize the formation of holding companies.
2. Incorporators may be non-resident.
3. Stock may be issued for property or cash. Judgment of the directors is conclusive as to value of property. The courts, however, have shown a strong tendency to accept circumstantial evidence of fraud.
4. Directors' meetings may be held outside of the state, if by-laws so provide.
5. Cumulative voting is permitted.
6. A voting trust, under certain restrictions, may be created.
7. Laws are all well adjudicated.

Disadvantages:

1. Stockholders' meetings must be held within the state.
2. One of the directors must live in the state.
3. There is an annual franchise tax; also an inheritance tax, but this does not apply to non-residents. Fees are from $25 to $1,000; filing fee, $10.

New York

Advantages:

1. Stock may be issued for cash, property, or labor. Labor must be distinguished from "services," though there is no decision explaining the exact difference. The ajudgment of the directors is conclusive as to value of property, provided there is no evidence of fraud.
2. Directors' meetings may be held outside of the state.
3. Corporations may hold and control the stock of other corporations.
4. Cumulative voting is permitted.
5. A voting trust may be created, limited, however, to 5 years.

Disadvantages:

1. Stockholders' meetings must be held within the state.
2. One incorporator and one director must reside within the state.

3. One-half of the capital stock must be paid in within a year from incorporation.
4. Detailed books and accounts of the business are required.

The first and most obvious factor to consider in selecting the state of incorporation is the cost. This cost consists of organization fees, annual taxes and counsel fees. The following tables, copied from a convenient manual by Thomas Conyngton, of the New York Bar, entitled "Corporate Organization," will give the reader an idea of how these expenses run in the five states which are most commonly used for incorporation by companies that expect to do business in other states:

COMPARATIVE TABLE OF ORGANIZATION EXPENSES
(Including all filing and incidental fees)

Capital stock company	New Jersey	New York	Delaware	Maine	South Dakota
$ 1,000	$ 35 00	$ 16 00	$ 25 00	$ 27 00	$ 13.00
5,000	35 00	17 50	25 00	27.00	13.00
10,000	35 00	20.00	25 00	27.00	13 00
25,000	35 00	27.50	25 00	67.00	13.00
50,000	35 00	40 00	25 00	67 00	18.00
100,000	35 00	65 00	25 00	67.00	18 00
500,000	110 00	265 00	65 00	67.00	23 00
1,000,000	210 00	515 00	115 00	117.00	33.00
5,000,000	1,010 00	2,515 00	365 00	517.00	113.00
10,000,000	2,010 00	5,015 00	615 00	1,017.00	133.00

COMPARATIVE TABLE OF ANNUAL FRANCHISE TAXES

$ 1,000	$ 1 00	$ 1 50	$ 5 00	$ 5 00	None
5,000	5 00	7 50	5 00	5 00	None
10,000	10 00	15 00	5 00	5 00	None
25,000	25.00	37 50	5.00	5 00	None
50,000	50 00	75 00	10.00	5.00	None
100,000	100.00	150 00	10 00	10.00	None
500,000	500 00	750.00	25 00	50.00	None
1,000,000	1,000.00	1,500.00	50.00	75.00	None
5,000,000	4,000.00	7,500.00	150 00	275.00	None
10,000,000	4,250 00	15,000.00	275 00	525.00	None

In those states where taxes and initial fees are small, the necessary expense for legal assistance is apt to be at a minimum, for two reasons:

first, because the state legislatures obviously are making a bid for the cheap incorporation business and will naturally make their forms and the necessary red tape of incorporation as simple as possible; second, because in such states incorporation agencies, which carry on their business on a wholesale scale, are in existence, and high-priced legal talent is hardly necessary. In other states competent attorneys should always be secured, and their fees may be expected to range from $50 up. In this connection it may be well to remark also that the necessary corporate records, which are the secretary's minute book, the stock certificate book, and the stockholders' register, may be obtained for from $10 to $500 per set. One of the cheaper sets is all that is necessary for most small companies. The reader now has sufficient data before him to form a rough estimate of the expense necessarily involved in the process of incorporation.

In choosing the state for incorporation, the advantages of having a charter from the state in which the principal business is to be conducted will often outweigh any disadvantages of high cost in fees and franchise taxes. In some instances, popular disfavor may be aroused by going to another state, especially if that state has a doubtful reputation in corporate matters. However, when business is to be widely scattered, so that license fees for the right to do business in several states are bound to be considerable, it is likely to be the part of wisdom and entirely honorable to incorporate under the law that may be found to hold out favorable terms.

CORPORATE POWERS

Under statutory provision, as has been stated, the corporation has tha right and power to the use of a name and seal, to perpetual succession, to hold property, to fix its by-laws and rules of procedure, to name its officers, to sue in court, to make contracts, to issue negotiable paper, and to perform the usual acts of a natural person in the prosecution of its business, subject to interpretation as to what constitutes that business and the transactions tributary thereto. It is evident that much of the ordinary business transacted comes under the implied powers incidental to the primary enactments. Dealing with property of all kinds, borrowing money, issuing bonds are instances of such implied powers. So accustomed have people become to dealing with corporations that little thought is given to the question, it being taken for granted that they can do all that an individual can do.

It may be that too little thought is given, since there are certain restrictions and limitations that deserve consideration.

These limitations fall under three main heads: accommodation paper may not be issued; the corporation may not enter into a partnership; and, in general, it may not hold the stock of other corporations. The last provision is not universal, and the only safe course whenever the question arises is to secure the opinion of attorneys versed in corporation laws in general and those of the state issuing the charter in particular. A type of corporation that is becoming increasingly common is the "holding corporation," chartered for the express purpose of holding stock of other companies. All three limitations arise from the contract relation with the state. A term in every contract of this kind is that stipulating the character of business to be entered upon. To do any of the three things mentioned is, presumably, to engage in the affairs of other parties.

The question naturally arises as to what happens if a corporation enters upon any contract involving such matter as may be outside the limits of its powers, the other party to the contract having acted in good faith and possibly having actually performed its part and so suffered detriment. Under the strict rules of contract law, a party can contract to perform only such acts as are legal. If the act in question is outside the powers of the corporation, then it is not legal, and the natural presumption is that there is no contract. It is a situation known in legal parlance as *ultra vires*. Adjustment of such cases is often a complicated and difficult matter. It is impossible to draw a hard-and-fast line between acts permitted under the implied powers and those distinctly outside. Court decisions have established, with reasonable definiteness, two rules applying here: (1) that a party that has received a benefit from the supposed contract may not set up as a defense the contention of *ultra vires*, and so avoid compliance on his part; and (2) that when both parties have fully complied with the terms of the agreement neither can plead invalidity of contract as a cause of action against the other. If no damage to the parties has resulted, so that it is a case of abuse of power only, then it is the state that must act if action is to be taken.

The preceding statements have been made with the private corporation only in mind. Engineers have many dealings with public corporations, however, especially with municipalities.

For such, the discussion can be only in words of advice. The man who deals with the public corporation without taking the precaution of inquiring into the legality of the enterprise and authority under which officials are presuming to act does so at his own risk and with his financial life in his hands. The only safe course is to consult a competent lawyer.

OFFICERS

The affairs of a corporation are administered by a board of directors elected by the stockholders at their regular annual meetings. It is usual procedure for the selection of officers to be left to the directors, but stockholders may exercise this prerogative if they see fit to do so. Various matters of business may come up at the meeting of the owners, but action taken is generally in the nature of establishing policies for the directors to carry through. The most important meetings are those held early in the history of the company, when the by-laws are being framed and put into effect. Care must needs be exercised at this stage in the operations.

The usual officers are the president, one or more vice-presidents, secretary, and treasurer. It is generally agreed that the president shall be one of the directors, but the others need not be. The vice-presidents are commonly men engaged in the active management of the several branches of the business.

The powers of officers are such as to make them agents of the corporation, and are specifically defined, subject to interpretation under the rules of agency. In this respect there is a clear distinction from the general agency relation which holds in partnerships. Only the designated officials have this power, and that according to provisions of the by-laws. It is the presumption that the president, as head of the company, acts always as its legal representative, by his acts binding the body. This is, of course, limited to those acts coming within the power of the corporation to do business, according to its charter.

Officers are liable for damages resulting from their negligence or wrong doing in office, to stockholders. Directors share in this responsibility within the range of action.

CAPITAL STOCK

Mention has been made of stock and the tacit agreement of stockholders to unite in carrying out the provisions of the con-

tract between the company and the state. Also, that the charter must state the total amount of the capital and the number of shares into which that capital is divided.

For the time it will be assumed that the amount of capital appropriate to the business on hand has been decided upon. It is customary to make the unit of stock, or the share, $100, unless the project is a small one, or unless it is the purpose to advertise the stock for sale among the population at large and to make it attractive to small investors. In this statement it is the industrial enterprise that is in mind. Eleemosynary and religious corporations may more frequently employ the share of small denomination.

Stock is of two kinds, *common* and *preferred*. That which has been referred to, to which the original stockholders subscribe, is common, and it carries with it the right to share in all the profits and the surplus of the company, and to other assets in case of dissolution. It entitles the holder to a voice in the control of the business, which the preferred may not do. Profits, known as "dividends," are divided pro rata to the holders of common stock after all current obligations have been met and the stipulated dividend paid on the preferred stock. The reprehensible practice of paying dividends out of capital, or from the surplus necessary for the safe conduct of business, is often resorted to in the endeavor to attract investors, but to condemn it seems hardly necessary.

Preferred stock is frequently issued, usually for the purpose of bringing in more working capital without increasing the number of persons in active charge of the affairs of the company. When profits are large, this leaves a larger margin for the holders of common stock, while at the same time it is a more attractive investment to the conservative person who prefers to hold preferred stock with its prior right to profits, even if the return is not so great. Dividends, while limited to some stated percentage as a maximum, are not guaranteed as is the interest on bonds, so that all regular expenses must be paid before any returns go to this stock. The full maximum dividend rate indicated at the time of issue must be paid before the common stock can receive consideration.

Under another classification, stock may be *full-paid* or it may be issued for payments in some amount below its par value. In the first case neither the company nor the creditors may assess

the holder for any further amount, which means that a stockholder is liable only to the par value of his stock for company debts, except in a few special cases. The company may sell stock below par and agree that it shall be non-assessable as far as the right of the company to call for further payment is concerned, but creditors may demand full payment in case of insolvency. When stock is issued in consideration for the rights of some person in a patent, or other means by which he brings to the company real value, the books of the company should show the transaction on a definite financial basis, so that this stock may appear as fully paid. Stock which is given for promotion rewards, or as bonus, has a somewhat precarious standing in the courts as regards the right of creditors to collect to its face value. "Watered stock" may be defined as stock which is issued at any time, for which no real value is paid in to add to the plant of the company. It is issued as "full-paid," which it is not, the difference between it and what of value it does represent, if any, being "water." The capital stock of a company cannot be increased without securing from the state official in charge of corporations, a new charter or the necessary change in the stated amount.

The preceding remarks as to watered stock are not to be interpreted to mean that stock may never in equity be issued to represent property values other than those actually paid in as newly invested funds. Stock, either common or preferred, is frequently issued in lieu of dividends, for the purpose of building up the capital for extensions of business. Debate as to propriety of stock issues to cover the reinvested surplus, when this surplus is what remains after a reasonable dividend has been declared and paid on all stock originally outstanding, occurs at times in the case of public service corporations. It would seem unjust in such cases to allow stock issues representing property that has been acquired through money collected in rates from the public, especially if future rates were to be adjusted on the basis of their being made sufficient to produce income that will be sufficient to pay dividends on the additional stock. It looks like a case of the public paying rates that were unnecessarily high in the first period, from which the invested surplus was derived, and then being asked to pay higher rates to furnish a profit on what they had contributed to the company. This is a vital matter in some instances of rate adjustment, as when value of the property is being fixed entirely by a study of book values and com-

pany history. It is a matter however, not appropriate for discussion at this point, but which will be dealt with in the section on valuation of properties. It seems clear that companies engaged in private industrial business may issue such stock without question, it being a matter of policy, pure and simple. The reason for thus adding to the outstanding stock, up to the actual value of the property, becomes real when extensions of business are being made. If capital stock is to be increased by placing new shares on the market, it is only fair that stockholders, under whose administration of affairs a surplus has accumulated, should receive full holdings, so that their control shall be proportional to what they bring to the new company as compared to the sums contributed by the new stockholders.

Dividends are declared by the directors as conditions in respect to earnings make them possible and desirable. When declared they stand as debts of the corporation to the stockholders, who may sue for their proportionate amounts. Accumulated surplus not apportioned as dividends at time of insolvency goes to the corporate creditors and not to stockholders, should it all be required for that purpose. Where more than one class of stock exists, the dividends may be declared for each class separately. All dividends must come from surplus or net earnings, however. This means that the dividend on preferred stock, commonly fixed in amount under the by-laws, cannot be paid unless the net earnings are sufficient to meet it. In other words, such dividend cannot be treated as interest on bonds, which is an expense of operation. Dividends may be declared to be paid either in cash or in additional stock.

Reference has been made to special liabilities of stockholders, the states of California, New York, and Minnesota being mentioned. In general, it should be said that the holding of a share of stock signifies only that the holder is entitled to that proportionate part of the assets of a company, or of the profits arising from business. Liability of the individual rests upon special statute rather than upon common law principles. One should, therefore, be informed, or take steps to secure information, regarding the statutes. A well-known provision is that holders of stock in national banks are subject to double liability, based on the par value of shares. In New York, in addition to general liability to the full par value, shareholders are liable to employees for wages due. In Minnesota, all except manufacturing corpora-

tions are held to double liability, as with national banks, in the interest of all corporate creditors. In California, stockholders are held to unlimited liability for all unpaid obligations incurred while they were stockholders of record.

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CHAPTER VIII

FINANCING THE COMPANY

The first consideration under this heading is the amount of investment that is necessary. At this point, however, one is brought face to face with the fundamental concept of industry in its financial phases, and must pause to clear the ground before taking up the consideration of the specific question of amount.

It is the object of organization of industry, in its broader phases, to adapt the specific enterprise to the financial system which governs business at the present time. The details of operations that are to be carried on, and which are bound to be influenced by the freedom of action possessed by the company as a result of its successful financing, must be in harmony with the economic facts. The company is a unit which must maintain proper relations with capital, income, operating expense, surplus, and profit. Haphazard financing at the outset does not represent the best thought in modern industry. More and more it is being recognized that careful planning is necessary at this point in the building of the enterprise. In his famous work on the "Wealth of Nations," Adam Smith laid down the principle that "consumption is the end and aim of production; and the interest of the producer ought to be attended to only so far as may be necessary to promote the interest of the consumer." In any interpretation of this statement, it must not be separated from the context. The author had been discussing the restrictive measures in vogue in England at that time, which represented an attempt to compel people to purchase articles produced at home. The restrictions applied even to individual cities in their relations with other cities in the same country. In much of his writing this exponent of economic theory held to the belief that, if let alone, men engaged in industry would finally adjust themselves to conditions on a basis which would make for sound practice.

The principle enunciated is a vital one. Someone has said more recently that "industry exists to adapt natural products to

human use." The thought is the same as that expressed by Smith, and in a process of gradual evolution people are now just coming to a realization of its true significance. The need of human beings is the foundation motive for industry, just as personal needs led to the first steps in barter and in trade. During the development of industry to its present complicated form, there have been two parties, capital and labor, claiming the right to consideration and to the financial returns. The time is approaching when the public, as an interested third party, will be recognized as one whose rights are to be respected.

The first interest of the consumer is that production may be made possible. In the language of modern conditions this means that materials must be produced, the goods manufactured, and the same goods delivered to convenient centers of distribution. The consumer cannot expect production to continue under other than profitable conditions, and hence it is for his good that industrial enterprises should remain on a permanently sound basis. This is so evident that it hardly needs mention, except to emphasize the point that industry cannot be on a sound basis, and therefore cannot serve the consuming public, unless it yields an incentive that will encourage productive enterprises. This incentive can be expressed only in terms of profit, or satisfactory returns on invested capital, as well as satisfactory return for labor in the form of wages.

Furthermore, in order that industry may be on a sound basis, it must be permanent. These two conditions are nearly synonymous, but the distinction is made in order to emphasize the fact that permanency in industry means more than the capacity of earning enough to pay current profits. The industry must be self-perpetuating. Perhaps there is no other element in financial dealing with industrial enterprise that is so difficult for people generally to appreciate. Profits may be distributed as dividends on capital, when sound accounting methods are employed, only after all the contingencies of the enterprise have been provided for. This means that the physical property must be safeguarded to provide the means for replacement as equipment wears out. It means that a surplus must be established to provide for the rainy day, represented by a year of business depression or misfortune. Out of income from goods sold must come the funds to provide for these contingencies. They must be allowed for on a definite plan, not by guesswork. When not thus provided for,

and the day of reckoning comes when someone must provide the funds that are necessary to maintain production, it is the consumer who pays the bill. The bill which he pays is not alone the amount necessary to renew the property, but on all future purchases he must pay the necessary return on an increased investment. The last statement may be challenged by some, on the score that the consumer has contributed the additional investment, and need not pay a return on what he has himself supplied, but the critic is reminded that this added investment was made necessary because the returns from industry were not sufficient during the earlier period to provide the reserves.

Inaccurate work and carelessness in the determination of the amount of initial investment are thus bound to result to the disadvantage to the consumer. The fundamental idea is that production is a natural function controlled by definite law. Capital has a definite part to play—to provide the means whereby the necessary operating facilities may be installed, the physical plant established, and the enterprise supported during the initial period when an income is being built up. It is not until the business has reached a level where income has assumed normal proportions, that the business is really self-supporting. Up to that time it is capital, initially invested, which supports the enterprise. The total amount of capital necessary must be fixed with a full and adequate consideration of all these contingencies. The tendency is to underestimate. The inexperienced promoter sees the necessity of creating the physical plant, but is prone to overlook the period of struggle during which the business is being built up to the point where it is self-supporting. As before stated, the result is to the disadvantage of producer and consumer alike, causing an unnecessary increase in the cost of goods. The same is true if the company is over-capitalized. Either way, the consumer pays the price, and while it may seem to make small difference to him whether the high prices are due to overcapitalization or undercapitalization, in the larger concept of business in the nation as a whole, it is of great importance to him that industry as a whole be capitalized adequately and sanely.

THE TRUE INVESTMENT

To illustrate the statements made in the preceding paragraph, the following example is given. A company, preparatory to

starting in business, issues stock to the extent of $200,000, realizing from sale a total of $180,000 clear of organization expenses. Of this amount, $150,000 is invested in land, buildings, and equipment, on the basis of which bonds are issued to the sum of $100,000. This latter sum is invested in additional equipment and working stocks, the remaining $30,000 being held as working capital. At the end of three years the company has reached the point where it is doing business at a profitable rate, but an audit of the books reveals the fact that during this period it has paid no dividends at all on its $200,000 of outstanding stock, has set aside no depreciation reserve, and requires the full amount of funds coming from earnings to balance its accounts and hold the $30,000 of working capital with which it started business. Its financial statement, expressed in simplest terms, would be as follows:

Assets, Book Value		Liabilities	
Physical plant and stocks.	$250,000	Stock .	$200,000
Cash and other current assets...	30,000	Bonds.	100,000
Resources supplied from income	20,000	Depreciation and other reserves .	
		Surplus..	
Total .	$300,000	Total ..	$300,000

On the basis thus indicated, the concern has been able to pay its bills and is now doing a good business. The question is, what is the total amount of capital investment? It is plain that the company is in a precarious situation without reserves or surplus in any form. The bondholders are safe, but the stockholders would be short on a forced liquidation.

The interest, or dividend, on stock has not been paid for the period of three years. This would amount, on a 6% basis, to $36,000. A proper depreciation reserve may not be indicated in exact figures without an extended discussion as to the character of plant equipment, but the most conservative estimate would be at the rate of 4% per annum on $150,000, amounting to $18,000. Other resources in various forms should have been developed during this time, so as to have created certain contingent reserves, amounting, we will say, to $10,000, and also a surplus at least sufficient to meet the interest on bonds for one year, an item of $6,000. These items total $70,000, which, in rough approximation represents the additional amount of

investment that should have been made in order to carry the enterprise through the formative and development stages and place it on a footing where it may proceed in an effective manner to produce the goods for which it was projected. Hence the correct amount of investment on this assumption would have been $370,000, so used as to increase earning power with which to build up current assets to more substantial figures.

All items mentioned as assets in the above statements are actual property items carried at book value. Nothing is said of what became of the $20,000 stock representing the difference between the total issued and the $180,000 received in cash. These shares of stock may have been given to promoters in return for their actual services and outlays during the promotion period. The amount indicated would not be an excessive one to be devoted to such purposes. Neither has mention been made of other forms of assets which a manufacturing concern might list at the end of the successful development period. These are "value of patents," "good-will," etc. It would not be difficult for a company management to add such items and convert the above simple statement into one showing a substantial surplus, merely by adding assets of the character mentioned. Unless money has actually been paid out for patent rights, however, such padding of assets would be questionable, if it is the desire to express the real status of the business from the standpoint of determining what the investment has actually been.

The object in view in presenting the foregoing statement is purely that of showing how necessary it is to take careful steps to prevent an enterprise from going on the rocks during the early years of its operation. Investors are entitled to their return from the time the stock is purchased. To consider the amount of such dividend return in the light of that much additional money invested, is not to advocate the reprehensible practice of paying dividends out of capital. At first thought, the two things appear to be related, but a careful analysis of the situation reveals an important difference. As pictured in this illustration, the undertaking is a bona fide movement to build up a successful enterprise. Investors have risked their money on the chance of an estimate of manufacturing possibilities being correct, and also on the effectiveness of the management which has been in control. It would have been unwise, however great the amount of invested capital, for the management to have paid in cash the amount of the

actual dividend, even though in justice the stockholders were entitled to it. The psychology of the situation would not have permitted such actual payment. Purchasers of stock should expect that earnings during the first years of active operation would be turned into the business to make secure their own investment.

Nevertheless, the actual true investments which have been made in the enterprise include the sum which might have been paid as return for the use of capital. In determining the actual value of the property of public utilities for rate-making purposes, it has been held repeatedly by the courts that this allowance for unearned interest should be made. It is the best and perhaps the most specific designation of what is commonly termed addition for "going concern" value.

The question may be raised as to whether allowance for this should be made in determining the amount of original investment that is necessarily made before starting in business. It may be argued that it would be impossible to sell securities on values not in existence. It is probably true that it would be impracticable, and perhaps unwise, to raise the amount as an actual cash sum prior to beginning operations. It may be better to let the business continue, hasten the accumulation of property through the reinvestment of net income, and then later adjust the investment securities to accord with the actual facts as to value of accumulated property. In the illustration which has been cited, however, the amount of property accumulated and utilized in the business is insufficient. There should have been a greater initial allowance for working capital.

The question would also arise as to the relative amounts of stocks and bonds. Discussion on this point will not be undertaken in connection with this purely hypothetical company statement, but will be treated in detail in succeeding paragraphs of this chapter, in application to the financial statements of several successful operating concerns.

CORPORATION FINANCE

Definition of Terms

Capital.—The term "capital" is used in so many senses and relationships that it is better not to attempt to give it an exact meaning for use in the present connection. It has become an

academic term rather than a specific term to be employed in the interpretation of business financial statements.

A brief discussion on the significance of the thing which is usually pictured as capital in the minds of people may not be out of place, however, at this point. The economist defines it as "the sum of the machinery and materials of production." This comes close to the meaning of the term "funds utilized," in which there are included all of the items of property value employed in the transaction of the business, corrected for the depreciation, so that only actual current value of property is considered. Debate would arise over the question of including items such as patents and good-will. It is obvious that the values represented by these items are being utilized in the business, and are also a part of the "capital" employed. It is questionable whether it should be included as a part of investment, except as the books may show actual amounts paid for patent rights or other evidences of property. Nothing is to be gained by discussing the intricacies of this question, therefore no attempt is made to bring the three terms into definite relationships with each other.

It is important, however, that there be determined for any enterprise, old or new, the proper amount which is to be considered as the foundation sum which measures the actual monetary strength of the company. On this depends the security and value of stocks and bonds. The public utility interests (with which are included the railroads in the present interpretation of the transportation policy of the country) are required to base their issues of stock and bonds on property values, these values being determined by processes which need special treatment, but which are quite closely related to the "investment" as that term has been outlined in the preceding sections.

When this base quantity that is to serve as a measure for the issuance of company paper is determined through a valuation of the physical property, with additions made to the same to give it a "going concern" value, the result may not be in accord with the actual book value of investment record. There are involved in any attempt to reconcile these two quantities--present value and investment or book value--such matters as variation in costs of construction at different periods, changes in land values, changes in prices of basic commodities like steel, the reinvestment of earnings, the question of adequacy or possible exorbitance in the charging of rates for service during the past years of opera-

tion, effectiveness and honesty in financial administration, and other points involved in the conduct of business under such management. But if capitalization is to be adjusted on the basis of the value of the physical property, it must be agreed that the slate is to be wiped clean and that a basic value is to be set, on which future financial policy is to be established. In no other way can the public service interests of the country be brought to an established basis, so great has been the manipulation of stocks in the past, and so varied have been the practices of management.

It may be that the public has supplied, through unduly high rates and tariffs, much of the money that has been applied to the creating of physical values. Contentious debates have been waged on the question, and some attempts made to "unscramble" the funds originating in the several ways. Some injustice undoubtedly attends the process of revaluing property on a physical basis and adjusting allowable earnings thereon. While the possibility that this may happen always exists, the fact remains that the public was slow in taking hold of the question to prevent itself from being defrauded, if defrauded it was. Anyone who has considered this question from the practical standpoint of the measures necessary to secure a record of true values is usually ready to say that nothing better can be done than to take the present replacement cost, with proper correction for physical depreciation for the period of service, as the basis for an adjustment of values to guide in future transactions.

The inclusion of this reference to property valuation at this point is incidental to the effort to make it clear that recognized investment values on which the owners are entitled to dividend returns may be quite a different thing from the actual amount of money which investors have themselves entrusted to the enterprise.

Candidly, then, capital may not be defined in quantitative terms so as to be of any significance to men dealing with practical affairs, although terms used in the measurement of capital may be so defined.

Capitalization.—"Capitalization" is a term to which has been ascribed a meaning as definite as the term "capital" is indefinite. It is used to represent the total of capital stock and bonds outstanding.[1] The word "outstanding" in the preceding sentence

[1] In another sense, "capitalization" is used to indicate the amount of the capital stock which the corporation is authorized to issue under the terms of its charter.

must be emphasized. A corporation, when chartered, has specified the total amount of capital stock which may be issued. For all practical purposes, however, what is of significance is the amount of this stock, both common and preferred, which has actually been issued by the company and is held by individual owners, together with the bonds which have been authorized over mortgage or debenture, and for which the company has received payment. The question of vital importance is the determination of the proper amount of capitalization which the property of a concern justifies. Three basic methods are employed in the adjustment of this relationship, and the one most appropriate is to be decided upon after a study of the special conditions which surround any particular instance.

The three recognized bases for adjustment of capitalization are as follows:

1. The basis of actual capital invested, or book value.
2. The physical value of the plant, determined by appraisal and estimate of reproduction cost, with proper additions for going concern.
3. The earning power.

The first of these methods is thoroughly sound in principle when the records of the company have been kept in a sufficiently accurate manner to make it possible to determine just what the investments have been. It is the method commonly followed by relatively small concerns which have little to gain from manipulative financing. Many important companies have followed essentially this practice, even though the actual value of plant and equipment has grown to an amount far beyond that represented in the total issues of stock and bonds. Where this is the case it means that the earning power of the company has been largely increased, so that the concern has the ability to pay large percentage dividends on the relative small amount of outstanding stock.

This possibility leads to a condition that is unfortunate, in that a certain amount of public dissatisfaction may be experienced over the payment of high dividend rates. In some cases it even encounters specific legislative prohibition, or the equally effective prohibition that comes from taxing excess profits. We will not stop to inquire at this point whether the property values were built up by the reinvestment of earnings which were

legitimate, or whether heavy profits were secured through measures which were questionable. It may be taken for granted that most of the industrial concerns here referred to were enabled to make their earnings through fortunate market conditions, and that methods prevailed which were straightforward and open.

When such an establishment confronts the condition where heavy payments to stockholders are both possible and reasonable, on the basis of value of the property and its earning power, a common recourse is to declare a stock dividend. The object of this is merely to increase the total amount of outstanding stock, so that in the distribution of net profits the percentage on par value of stock will be diminished. The stock dividend is declared in the same manner as the ordinary dividend, but is paid in new stock instead of cash. Frequently the stock used in payment is a new issue of preferred stock bearing a fixed rate of interest, the payment of which would absorb a considerable portion of the earnings to be distributed in the future. The increase in the amount of stock outstanding may be brought about simply by declaring a new issue based on the actual values of the property employed in the business.

It is assumed here that in all cases there is actual property value behind the new stock. This brings it legitimately within the definition of the first method, wherein the total amount of outstanding securities is based strictly on values of property as revealed by the property account carried on the books. In the examination of financial statements to be discussed in the following paragraphs, reference will be made to the quantitative relationship which should be observed between the amount of these securities and the value of actual property.

The second method differs from the first only in respect to the process employed in determining the value of the property. The capitalization is to be held to a justifiable ratio with the property value, as in the first method. The difference is that the value of the property has been determined by appraisal rather than by company experience registered in its own books. As is well known, the capitalization of public utilities is determined regularly by this method, but, except for purposes of sale or taxation, it is unusual for the privately owned establishment to employ this method of arriving at values.

The third method is one which has been employed extensively in the handling of industrial properties. Arguments in its

favor are strong, but there is need for the employment of keen discrimination between the elements which make for value of stock and bonds on exchange and the elements which make for the guarantee of the safety of company paper.

This method is that of capitalizing the earning power. That is, the concern which has an earning capacity of, say, $60,000 per year, will pay a 6% return on $1,000,000. The concern might then be capitalized on the basis of the $1,000,000, irrespective of the actual amount which had been invested originally by the founders of the enterprise, and irrespective of the actual value of the property employed. The situation calls for a bit of careful analysis. From the standpoint of those who favor this method of financing, it is well understood that the value of stock is directly dependent upon the earning capacity. Assuming that the entire amount of outstanding securities is in the form of a single issue of common stock, taken thus for the sake of simplicity, the paying of current dividends that are above the rate generally considered satisfactory as interest on loans at once causes the stock to sell at a high rate on the market. If, for any reason, the amount of outstanding stock is to be increased, to avoid excess profit taxes, or simply to bring the rate of dividend to a reasonable figure, advocates of this method will argue that it is well to go as far as possible without causing so great a drop in the dividend rate as to drive the stock on the market below par. Those who are adjusting the stock issue from the standpoint of the stock market follow this line of reasoning.

The practice is not to be condemned out of hand. When it is exercised with caution, no bad results need follow, although at heart it is a speculative proceeding. It has the speculative feature because the values that are being dealt with are those which depend upon the dividend record of the past and on the degree of confidence which buyers of stock may have in the management of the company. The proposed capitalization is not based on intelligent analyses of producing and marketing conditions, or the progress of related industries. Any one of many causes, internal or external, competitive or favorable, may bring about a pronounced change in the earning power that will throw it quite out of harmony with past records. To reason entirely from stock market records is to accept business judgment at second hand. Confidence in the management to sustain the earning power is a different thing from basing action on the

confidence which arises directly from a first-hand analysis of the conditions which affect business. Between the business and the trading in securities on the stockmarket lies human judgment, with the tendency toward optimism, which is an expression of confidence in the ability of the company management to maintain earning power.

In brief, strong as is the influence of stock prices as related to dividend-paying capacity, and logical as may be the variation in significant values of company paper, there is an element of danger in this third method of adjusting capitalization. The first duty which the management owes to its security holders is that of making safe the investment. This is accomplished by accumulating the real property values that stand behind stock as well as bonds. It may be said that to place in the hands of a stockholder two shares of stock, where previously he held but one, with no additional payment required from him, leaves him with the same amount of equity in the enterprise, and he would receive just as much on the dissolution of the business as if the expansion in stock had not taken place. There is truth in this statement, but there is the other pertinent fact that in case of diminished earning capacity the value of the two shares of stock on the market will suffer more than would the one. This fact is not readily explained, but it is true. It is based on human nature rather than on the mathematics of the situation. Psychology figures largely on the stock exchange and the condition cited is one of significance.

Enough has been said to indicate the real principle which must needs guide in the adjustment of company capitalization. The real basis which makes for safety is the value of the property employed in the business. The three theories discussed represent three different methods which are employed in arriving at an estimate of the value of property. Fundamentally, there is but the one consideration. Care and conservative judgment must guide in order that confidence may be maintained, because on confidence rests credit. Business enterprises are successful in proportion as they enjoy and utilize credit. It is a thing which is closely related to capitalization and to actual property values. Numerical analyses which follow in succeeding paragraphs will reveal characteristic figures for this ratio.

Stock and Bonds.—The preceding section devoted to capitalization has taken for granted the reader's knowledge of the general

character of these two forms of securities. Capital stock has been discussed in the chapter on "Organizing the Company," mainly with reference to the technique of corporate organization. The actual amount of outstanding stock, or stock which has been actually issued by the company and for the redemption of which it stands liable, may be a very different quantity from the total authorized capital stock specified in the charter. The actual amount of cash received in the treasury of the company for the stock thus issued may differ materially from the par value. Common stock has been issued many times purely as a bonus to encourage the selling of preferred stock and sometimes of the bonds. Practice in this respect is changing gradually, and under existing state laws there will be a closer relation between outstanding stock and cash received for it. In the illustrative exercise in the first section of this chapter, essentially full payment at par was assumed on the outstanding stock.

Stock which has been bought back by the company is no longer an obligation to be met and should be held as treasury stock, subject to future sale if conditions make it desirable. It is inert paper so far as the actual statement of operating finances is concerned.

A bond issue is in all significant respects a long-time loan. It must be based on actual property values which stand as security for the issue. Without this security, bonds cannot be sold. Bonds are designated as mortgage (first mortgage, second mortgage, etc.), debenture bonds, income bonds, special equipment bonds, etc., according to the character and availability of the property which secures them. The relation between first mortgage and second mortgage bonds is exactly the same as that which exists between first and second mortgages on a section of land. This difference is well understood by all who have any knowledge of financial matters. The value of the second issue depends entirely on the margin of value which the property possesses over and above the amount of the first issue.

The debenture bond differs from the mortgage bond, in that it is based upon what is essentially a promissory note, properly executed, but not assigning any specific item of property as security. Its value depends on the general financial responsibility of the company executing the note. It may be said that earning power plays a larger part in securing this type of bond than the actual value of property, and this may be true in many

cases. It should be an established policy on the part of a company which has issued bonds of this character to provide for their retirement out of earnings within a comparatively short period.

The income bond is a variety of paper still farther removed from actual property backing. In fact, it partakes very largely of the character of preferred stock, without voting power.

Special equipment bonds, as the name implies, are secured by specified classes of property. Railroad companies are almost the only ones which have made use of this form of security. Car equipment bonds have frequently been issued for the purpose of financing increases to equipment, the equipment itself being given as security.

The Depreciation Reserve.—While depreciation is a matter of primary concern during operation, it is not to be overlooked in a consideration of original financing. It is necessary that it be understood fully when studying the financial statements of operating concerns for the purpose of determining significant ratios that may guide in furnishing the necessary equipment. It is the reserve to cover depreciation, and its influence on financial problems, that are to be considered at this time, rather than depreciation itself.

In general, depreciation represents the change in the value of property during periods of time. It is a loss which takes place much more rapidly during some periods than during others. Heavy machinery placed on foundations suffers a considerable loss in value because of the expense that would be involved in moving it to any other location. A law for calculating the actual amount of the depreciation loss which gives larger figures for the early years is appropriate, therefore, for such classes of machinery. A rule more generally followed, however, is to assume the straight-line law with a uniform loss each year of the operating life of the property. Further than this, reference will not be made to the methods of calculating the actual change in value. It should be noted, however, that some types of property, notably land, may suffer an actual increase in value, which means a negative depreciation.

It is clear that in determining the actual amount of funds being utilized at any particular time in the operation of the business, the figure should be based on the true value of the property items at that time. This means that the depreciation reserve is

to be deducted from the original or book value of investment in the plant. This gives what may be termed the "present value." There are two methods employed by accountants in taking care of this matter. One is to adjust the value of the several items in the list of principal assets, such as buildings and equipment, so that these appear at their true values at the time of preparing the statement. If the plant is operating year after year with slight change in the amount and general character of the equipment, this means that the books will show in the property account a gradually diminishing value. Rather than do this, others hold the property values at an approximately constant level and show a gradually increasing depreciation reserve. This reserve account is a liability, since it represents an obligation which the company must meet in any final adjustment of its affairs. In finding the actual amount of funds utilized in the enterprise from the figures of a balance sheet, where this practice is followed, depreciation reserve must be deducted from the apparent value of property.

The handling of a depreciation reserve is a matter which causes much confusion in the minds of the inexperienced. Any thought of it as a real reserve suggests the existence of a sum of money set aside for no apparent purpose. Under some circumstances it may be good policy actually to keep a limited amount in reserve when it is evident from the condition of the equipment that the time is near at hand when equipment items must be replaced, made necessary either by the old being worn out or having become unprofitable because of improvements, but this is not often the case. When thus actually set aside in reserve, the money is presumably drawing some rate of interest in the bank, and it will appear in like amount on the asset side of the statement, either in the general item of cash or in a separate item.

But it is evident that to keep money on deposit where it will draw but a low rate of interest is an inefficient utilization of funds. No industrial enterprise can be considered satisfactory unless it is paying much larger returns on investment than would be paid for money deposited in any bank or trust company. The logical thing to do, therefore, is to utilize these funds in the building up of the equipment of the plant, or the creation of more adequate working capital represented in stocks of material on hand, which represent purchases and consequent investment of money at times when market conditions are especially favorable.

This gives rise to the thought that when the reserve is tied up in the business it is not available for purchasing new equipment to replace the old. In a measure this may be true. The suggestion in the last paragraph pertaining to the holding of a limited amount in more liquid form was made with this in mind. In general, the replacement needs may be estimated for long periods in advance and plans may be made accordingly, thus safeguarding the situation. Should particular emergency arise, the added equipment and material which has been supplied through the utilization of the reserve fund by reinvestment in the business may be made the basis for a bank loan, probably at interest rates not out of proportion to the rates that are being received on the money as invested. In these ways, according to the sound judgment of those who are in control of operation, the depreciation reserve is handled to the best interests of the organization. In interpreting financial statements, it is to be observed that the equivalent of the depreciation reserve carried as an item on the liability side appears somewhere on the asset side in the guise of equipment, materials, or cash.

In passing, it may be remarked that various special reserves are explained in the same way. Reserves are frequently provided to take care of accrued interest on bonds or loans, to take care of interest coming due in the near future, for the carrying out of specially designated lines of work, or for replacements and betterments. All such impending expenditures are treated as obligations soon to be met. The actual funds from which payment will be made appear in cash or other items in the asset column, such as short-time investments or securities of other companies readily convertible into cash. Successful operation demands that funds of this character be retained in a form sufficiently liquid to enable the company to meet its obligations without the annoyances which are destructive to credit.

SURPLUS

In the developing and handling of surplus the company manager meets one of his important problems. Consideration must be given here to several of the questions of policy which have a most vital relation to the safeguarding of securities and to the development of confidence in the enterprise. A wise management must sometimes oppose the stockholders, who are interested largely in the size of the dividend declared upon the

stock, and who may not have the vision to foresee the benefits that will come from a gradual building up and strengthening of the company resources.

There are several sources from which a surplus is derived. If the company property be revalued during a period of advancing prices, and the several items listed at the rates which correspond to the purchasing prices of the day, there results a larger total of company assets, the same being reflected in the increase of surplus, which is merely a difference between the total assets and all direct liabilities. The same result comes from the inclusion of such items as franchise value, good-will, value of trade marks, or other forms of intangible elements in the earning capacity of the enterprise. It is possible that in some instances this is legitimate practice. A calm consideration of the actual facts in the case will generally lead one to the conclusion that it is unsound, however, and is likely to result in the creation of suspicion. It surely does not represent anything which will go far in safeguarding the holdings of the stockholders in case of stringency or suspension of operations.

Another source of surplus is the selling of plant equipment which has been fully covered by depreciation reserves and is said to be written off the books. If depreciation has been handled properly, and any item which is technically of zero value on the company's books actually returns an income on sale, the sum thus realized is a genuine addition to the assets of the company. It appears in cash, accounts receivable, or other evidence of property. As before, the amount shows up in the surplus.

The really significant source of surplus, however, is saving from earnings. Conservative handling of the affairs of a successful enterprise will always result in the setting aside of some portion of the gross profits to surplus. It is impossible to give exact estimates of the amount of surplus necessary or desirable from the standpoint of service in meeting unexpected contingencies, such as excessive depreciation or the unavoidable losses of bad years. Enterprises differ radically in their susceptibility to variations of this sort and the judgment of those who are intimately concerned with the administration of the business must be the guide.

There is another form of consideration to be given to the surplus, which has to do with the utilization of funds when the accumulation has passed beyond the sum necessary for equalizing

the variations of the years. In the early years of any enterprise, investors are wise to put into effect a policy whereby dividends, if declared at all, shall be small, in order that the surplus may build up rapidly and the property be gradually improved to insure increased earning capacity. Many concerns have been built up to positions of great strength and eminence in the business world through the reinvestment of earnings. Sometimes this has been carried to a point where stockholders become impatient, but usually the impatience gives way to a profound satisfaction when conditions arise which reveal the tremendous value which a large surplus has for the stockholders. A striking illustration of this is afforded in the record of the Carnegie Steel Company at the time it was sold to the United States Steel Corporation. In the cases of a great majority of the stockholders of that company it was undoubtedly true that the accumulation coming from the great earning power which the reinvested surplus possessed in the concern was vastly greater than could have been realized by individual stockholders had they been handling their dividends separately.

The question arises as to the propriety of issuing additional stock for the property accumulated through the reinvested surplus. This has been a fruitful source of argument and controversy in cases of public and semi-public enterprises, such as the railroads. It is clear that where real value exists in the form of plant equipment, there can be no question as to the soundness of the backing enjoyed by such additional stock. In other words, this is not "watered" stock, but is paper based on sound property values. The question is merely whether the original investors have the right to possess this property and to receive dividends based upon it. No attempt is being made to carry the question through to a final answer, but one observation is made, namely — to the extent to which the original stockholders sacrifice their dividends, the reinvestment of that money through the avenues of the enterprise resulting in an increased earning capacity, so far may it be said that in all justice those stockholders are entitled to the returns which are a result of sound policy and good judgment. The accumulation thus justified is far greater than the actual amount of the dividends which were sacrificed, because the accumulation has been a multiplying and reduplicating process, where small beginnings have assumed large proportions.

ANALYSIS OF BALANCE SHEETS

A typical financial statement of a company, when one is able to interpret it, contains much valuable information. It is an index both of its operating condition and of the soundness of policy which has governed the management. It is important to know the ratio of certain liability items to corresponding asset items, in order to estimate the ability of the concern to meet its obligations. These ratios are to be discussed with reference to the following typical balance sheet. This sheet is a close parallel to an actual statement for an operating company which was in good condition. It may be taken, therefore, as a fair index of sound practice, illustrative of a manufacturing enterprise.

Balance Sheet of the XYZ Company

Assets	
Real estate and buildings	$ 322,000
Machinery and equipment	534,200
Stocks on hand, raw	194,326
Stocks on hand, finished or in process	217,250
Bills and accounts receivable	302,529
Cash on hand and in bank	240,462
Liberty bonds (market value)	19,200
Sundry investments	65,400
Patents and good-will	115,000
Total	$2,010,367

Liabilities	
Capital stock, common	$ 400,000
Capital stock, preferred, 7%	300,000
First mortgage bonds, 5%	400,000
Bills and accounts payable	391,486
Bond interest due	15,000
Contingent reserves	44,000
Employees' benefit fund reserve	20,000
Depreciation reserve	218,500
Surplus	221,381
Total	$2,010,367

For use in further analysis of operating conditions the following item from operating account is appended:

Annual sales.. $1,924,000

It is necessary to define certain terms which are employed in dealing with such statements. The first of these is *Capital Assets.* This group includes such property as real estate, buildings, machinery, and patents, in the case of manufacturing plants. A holding company, this being a corporation formed for the purpose of holding the stock of other concerns, would class the securities of subsidiary corporations in this group. Intangible assets, such as good-will, trade marks, etc., belong in this classification.

Another is designated as *Current Assets.* This group includes all the property that could be disposed of without actually breaking up the business. Within it come such items as stock of other companies, when control of those companies is not necessary for the primary business, materials and stocks on hand and in process, finished goods on hand, accounts, bills, and notes receivable, and cash.

Within the current asset group are included the items of cash, accounts receivable, and certain others which may be turned quickly into cash in case of emergency, the total being known as *Quick Assets,* or sometimes *Liquid Assets.* The test in this division comes on the point of whether the property is of such a character that in the event of possible financial stringency cash may be realized on it without delay.

There is the corresponding group of liability items known as *Quick Liabilities,* made up chiefly of bills and accounts payable. This should include the item of interest due, as well as other obligations which must be met at once in case of emergency.

Net Worth is found by deducting the debts from total assets. *Debts* includes bonds and other outstanding securities, bills and accounts payable, and other current obligations and reserves. It is apparent that net worth is the sum of capital and surplus. It represents the real amount of interest or equity possessed by the investing stockholders in the business. For some purposes of analysis, preferred stock would be considered as debt, and the net worth of the holdings of common stockholders investigated on this basis. Whether this be done depends on the character of the preferred stock as regards the degree of control which it carries. In many instances both common and preferred stock are held by the same persons in more or less the same ratio, so that the first interpretation of net worth is the more significant.

Other divisions of the property, not so commonly employed as those which have had specific titles assigned to them, but which are, nevertheless, of real significance in analysis are:

Funds Utilized, which include the direct property items of plant and materials, stocks on hand, bills and accounts receivable, and cash, less depreciation reserve. The reason for deducting the depreciation reserve has been noted in a preceding paragraph. It is to be noted that the group includes all of the property actually employed in the business, accounts receivable being included because it is understood that the company is utilizing its credit which is in turn maintained in part by these receivable items. Intangibles, such as good-will, are omitted. It may be that patents are utilized in the business to the value of their actual cost, but in the sense in which the term is here used the item is not considered.

Plant.—Under the designation of *plant* are included the items of land, buildings, and fixed equipment at their depreciated value. These form a portion of the capital assets.

Borrowings include bonds, bills and accounts payable, and any other item which indicates that funds supplied by an outside party are being retained for use in the business. Under this definition accrued interest might be included, but normally it would not be, unless for some reason the payment of interest were being delayed for a considerable period of time.

For purposes of analysis, the items of the balance sheet may well be arranged on the following plan:

ASSETS

Cash	$240,462	
Receivables	302,529	
(These constitute quick assets.)		
Stocks	411,576	
Securities and investments	84,600	
Current assets		$1,039,167
Plant—fixed assets (less depreciation)	$637,000	
Patents and good-will	115,000	
Capital assets.		752,700
Total assets		$1,791,867

LIABILITIES

Bills and accounts payable	$391,486	
Bond interest due	15,000	
(These constitute quick liabilities.)		
Current debt		$ 406,486
Reserves	$ 61,000	
Funded debt bonds	400,000	
Total debt		870,486
Capital stock	$700,000	
Surplus	221,381	
Net worth		921,381
Total liabilities		$1,791,867

Other quantities which are of significance in the analysis are:

Funds utilized	$1,592,26
Capitalization	1,100,00
Borrowings	791,48
Sales	1,924,000

On analysis the above figures show the following significant ratios:

	PER CENT
Quick liabilities to quick assets	71 7
Quick liabilities to current assets	39 1
Capitalization to funds utilized	69 0
Borrowings to funds utilized	49 7
Bonds to plant	62 7
Net worth to plant	144 5
Net worth to total debt	105 8
Net worth to funded debt	230 0
Net worth to capital stock	132 0
Sales to funds utilized	121 0
Sales to net worth	209 0
Sales to plant	302.0

The significance of these various ratios is readily apparent. Quick and current assets, manifestly, should show ample margins over the quick liabilities. The figures shown for the balance sheet in question are conservative.

The ratio of capitalization to funds utilized, 69%, is low, but represents a conservative business. It is here that the practice

of any concern which sets a high value on intangible values, such as patents and good-will, will show up to disadvantage. Many operating concerns, some of them flourishing, are capitalized at over 100% on this basis. It must be admitted, however, that a more moderate policy in this regard is better, and concerns really sound have held the stock issues down to figures such as those represented in the illustration. Each general principle has its exception, however, and there are certain notable enterprises in the country, the value of whose trade marks or good-will is a very real thing and amounts to a considerable portion of the assets which make for earning power. Under such conditions it is justifiable to capitalize on that basis. The conclusion is that sound judgment must be used in assigning a value for good-will in amount such that this ratio is materially affected.

Borrowings to funds utilized, and its closely related companion, bonds to plant, have specific significance and it is never safe to allow the percentage to run above some such figures as those indicated in the illustration. When the plant includes large land holdings, the ratio might be slightly greater than 63%, since land is the safest class of property on which to issue bonds. Where buildings and equipment figure materially in the total, 50% is a better rate to observe. Much the same statement may be made with respect to the total of borrowed funds in proportion to the total funds utilized. Usually the banks may be depended upon to see to it that credit is not extended beyond safe limits, but the plant executive must keep such facts in mind in connection with his planning.

The several ratios of net worth to the quantities listed may be considered in somewhat the same connection. It is seen that for every $100 represented in common and preferred stock combined, there is net worth to the amount of $132. The ratio of worth to total debt is not so good. The ratio should be considerably higher to insure freedom from the danger of pressure from creditors. We see a situation in the affairs of this concern where the total debt $870,486, is greater than the capital stock outstanding, $700,000. As the proportion of debt increases over the funds invested by the stockholders, the company becomes more dependent for working capital upon the decisions of its creditors, and more susceptible to pressure in time of crisis. It is a point that should be watched with great care. Many concerns show double this ratio. The ratio of net worth to plant

gives the same indication as bonds to plant, noted in the preceding paragraph. The ratio, 144.5%, is rather low, as 62.7% for the ratio of bonds to plant is rather high. Apparently this concern is developing its current resources out of proportion with the capital assets.

Comparison based on the amount of annual sales is introduced here solely for the purpose of suggesting the amount of annual business that a plant should have in order to justify its investment. The concern is here shown to be doing only a moderately active business, turning its funds utilized only 1.21 times per year. The capital stock, common and preferred combined, is turned 2.75 times per year. The figures are fairly representative of manufacturing plants turning out various lines of heavy machinery and bulk commodities. This group of ratios should be very different for other lines of business, however. In light goods, and particularly commercial pursuits, the ratio must needs be considerably greater than these in order to meet the competitive situation.

In order to study the type of administrative policy that is governing any organization, it is necessary to have at hand the balance sheets showing conditions year by year for a considerable period. This will make it possible to determine with a fair degree of accuracy the conditions under which the company has been operating, presumably during years which have shown good business, as well as bad, in former years. The test of time thus serves to give an index by means of which the effectiveness of the administration of the business may be judged and suitable operating ratios established. A statement for a single year fails to give this general index, and one business may not be judged specifically by another. Each line of enterprise has its own peculiarities as to investment and volume of business, so that the operating ratios which have been found for the one balance sheet should not be followed too closely in estimating either good or bad tendencies in other enterprises. General guiding relationships may be kept in mind, however, and may be made to serve when employed conservatively, especially in such a vital element as bonds in proportion to plant. Another typical balance sheet representing a reasonably prosperous concern, is reproduced in the section of this book devoted to exercises to be solved by students. The results secured from its analysis are to be used in checking those which have been found for the above.

PROCEDURE WITH THE NEW ENTERPRISE

In this consideration one is carried back to the original proposition in this chapter, namely—the determination of the amount of investment necessary for his business, and how this investment shall be represented by the various classes of securities. A study of the practices of various concerns, as revealed in their balance sheets, has afforded guidance to the organizer who considers the situation carefully and thoroughly.

It is to be presumed that the promoter has passed through the states of preliminary plant design discussed in Chapters III and IV of Part I, or that he has at hand information which has been gathered by technical experts. If the marketing campaign has been accurately projected, he knows approximately the magnitude of business to be undertaken. He should know the approximate size of the plant that is to be constructed, and in reasonable detail the extent and general character of the apparatus, from which estimates of plant cost will be made. This serves as a preliminary guide on which may be based estimates of first needs and ultimate bond issues. The amount of working capital necessary to handle effectively the working force and establish proper credits with banking institutions may then be approximated. In this the nature, amount, and value of raw materials will figure. The faster the goods are turned, the less the necessary working capital.

The table of relative values of significant operating items for 50 selected industries at the end of Chapter II may be referred to in this connection, but caution should be exercised in estimating on the basis of the figures there given for capital. It is well known that data on capital taken from the reports of the U. S. Census Bureau are very unreliable, largely because of the fact that manufacturing industries have not followed effective bookkeeping methods in the past, which would make possible the gathering of reliable information. Figures from this table may have a real usefulness when employed as checks on other estimates, but beyond this it is not wise to go.

It is customary to estimate in advance the cost of plant and related equipment, corresponding to the items of real estate, buildings, machinery, and equipment in the typical balance sheet. In doing this, certain units are adopted on the basis of which cost data have been calculated from past experience. The cost of railroads would thus be estimated on the basis of

mileage, the cost per mile being a matter on which men of railroad experience would be well qualified to estimate, after a preliminary survey. The cost of utility properties may be estimated—electric power stations on the basis of cost per kilowatt capacity, water works on the basis of cost per million gallons per day capacity, highways on mileage corresponding to the conditions on railroads, and similarly with various other forms of utility improvement. For the general manufacturing concern, the promoter may have his plant cost estimated on the basis of producing a fixed quantity, determined by the demands of the market or by some arbitary ruling; or he may have proceeded on the basis of number of employees as an index of the size of establishment. However this may have been done, experience is the only guide for the final estimate.

With the item of plant cost determined or selected, he may then pass, by means of some of the ratios which have been suggested in the preceding discussion, with an admixture of judgment and common sense, to a conclusion as to the total capitalization necessary. As before noted, a generous allowance should be made for working capital.

It is not to be expected that the full amount of capital will be paid in and made available at the outset, and in many instances this would be unwise, even if it were possible. In determining the relative amounts of common or preferred stock, as well as of bonds, it must be recognized that a certain amount must be paid in in cash on the form of security that assumes the risk in order that a start may be made. With these initial funds, fixed assets must be secured in the form of land and buildings, following which it may be possible to secure, first, temporary loans for the acquiring of additional property, and, finally, the acceptance of a mortgage to constitute the basis for a bond issue. It has been the practice of many concerns to acquire funds for the initial expenditures from an advance sale of preferred stock, a certain amount of common stock being thrown in as bonus with each share of preferred. If the ratio thus established between capitalization and funds to be utilized were to continue, it would mean a capitalization running very high in proportion to business. This would be the situation in any case for the first years of operation, during which time no dividends on common stock would be expected. It is here that the proper use of the surplus becomes of significance. By a wise policy of reinvesting earnings in the business,

there will ensue a gradual building up until the value of property, of both fixed and current assets types, bears a satisfactory proportion to the capitalization. At this time common stock, if issued in the manner indicated, would acquire a real value. It is thus that the stockholder may receive his share of plant earnings, even though he has foregone dividends through a considerable period of years in order to build up the surplus.

A more conservative method at the start is to sell both common and preferred stock only on payment in cash to the full par value. Should it become desirable to issue stock faster than the money can be used effectively, resort may be had to the practice of selling below par, the stock being issued as having one instalment paid, each share subject to assessments at future times in accordance with the needs of the company. This method is successful where a relatively small number of interested parties are taking the stock on a subscription plan. General stock selling to the public is rarely successful, however, unless the stock is issued as "full paid and non-assessable." Even though the full price is not paid, this means that the company cannot collect additional payments, even though creditors of the company may collect from the holders of such stock up to the par value, or to other ratios in accordance with the laws of the incorporating state with respect to stockholders' liability.

In the early stages of business procedure it is of the utmost importance that accounting methods should be established that shall be adequate. A characteristic feature in successful modern business is accurate knowledge of conditions relating to costs. Capital investments on which dividends must be paid to insure the reputation of the enterprise, the maintenance of property that can be insured only by a sane handling of depreciation allowances, as well as all of the matters of routine business procedure—all depend upon accurate accounting. The modern theory of cost is that not only the facts, but the reason for the facts, shall be at the command of the responsible executive. The main reasons for knowing costs are that executives may know how to proceed to reduce them, and that sales managers may know prices at which to sell. At no time are these two functions of greater significance than during the opening period of business.

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NOTE: The later editions of the A. H. Institute series are numbered differently from the earlier one, and contain a new treatment of Corporation Finance by W. H. Walker in place of Lough's.

P.F.W.

CHAPTER IX

ORGANIZATION AND MANAGEMENT

A—Executive Control

The primary object in organization is *control*. All considerations are to be centered around that one primary objective.

The guiding element in the determination of type and form is that organization is a means to an end. It is the agent of administration, and as such merits attention.

These two foundation principles must be kept always in plain view. There is a tendency to overstress organization through elaborate planning. The means are frequently mistaken for the end. What is needed here, as in all other phases of administration, is sane judgment in weighing the needs of a situation. Internal lines of control fix the means of contact of the human factor, labor, with the other factors representing the material side of industry. This contact must be real and must be in accord with human nature. Control lines when once set are not readily changed. Clear vision of the aims, and understanding of the nature of the forces to be controlled, are the first requisites to success in planning an organization.

The aims are:

1. To systematize operations and so fix responsibilities for the several members of the operating staff.
2. To secure effective coördination of effort.
3. To bring out the best efforts of the managing staff through specialization, each in his own field.
4. To subdivide the work in large enterprises so that the activities of each member will be within his power to exercise effective control.
5. To build up morale and friendly relations between workers and responsible members of the managing staff.

Production Principles.—Operation of modern industrial enterprises centers around three production principles: *standardization,*

specialization, and *mass production*. The ideal establishment is one that is in correct relation to all of these. It may not be developed to the highest degree of perfection in all, since limitations of size and scope may prevent, but it will be in logical relation to them. For instance, it is not feasible for some manufacturers to adopt mass production. The principal product may be of the special order variety. Nevertheless, there are certain phases of production, on parts that have been standardized, it may be, or through adaptations of the system employed in grouping orders and passing material through the plant, where methods corresponding to mass production are possible.

It becomes clear, on consideration of this general proposition, that large establishments have advantages. The day of small enterprises has passed, generally speaking. By this we do not mean that all plants must be huge affairs. In some lines good-sized factories are small compared with good-sized factories in other lines. They have grown from different beginnings. But in their several degrees of largeness they have gotten beyond the old fashioned small-town shop, where each worker performed several kinds of work and had personal contact with the product. A newer plan for effective coördination of effort is required, which rests upon good organization of the forces of production, and in which these three principles figure heavily.

Standardization has been the aim of production and designing engineers since modern factory methods had their beginning. What at first might seem to be a simple matter of establishing standard screw threads took years of effort by technical and business organizations to bring about. In the wider business world we still have diverse systems of weights and measures. Standard specifications, standard names for machine parts and tools, a standard general nomenclature—these and others are ideals toward which industrialists are working. Within individual plants it has been found convenient, and a common sense provision, to fix standard sizes of drawings together with uniform methods of detailing structural parts; to specify tolerances or limiting dimensions, thus setting the limits within which workmen must finish parts of machines or structures that are to be fitted to other parts; and to enforce rules to compel designers to employ standard fastenings, fillets, and symbols in their designs. These are matters of technique, in the main, but the management still has occasion to give them attention.

No single phase of plant design is of more significance than standard equipment. It is often remarked that a plant fitted throughout with equipment of second-grade quality is better than if fitted with part first-grade and part second- and third-grade quality. Workers on the best machines will be compelled to be idle at times, waiting for work that has been delayed by interruptions due to defects on the poorer ones. Unconsciously, perhaps, the production rate will be determined by the poorer portions, and delayed still more because of lowered morale of the force, caused by idling on the better portions. In other words, teamwork is impossible with heterogeneous equipment. This is distinctly a matter for the management to guard against, and suggests a provision in the plant organization for a competent foreman and crew on maintenance and adjustment of operating machines. This is nothing new in plants where equipment and process control, as in textile mills, flouring mills, etc., but in metal working plants it was neglected for many years on the theory that the operators should keep their own machines in order. In most industries it is given less attention than it deserves.

Closely linked with equipment is the setting of standard performance, or tasks, for workers. Here we confront the debated question of time studies, motion studies, and the like; also the fixing of such matters as depth of cut, feed, and speed for machine tool operations, and equivalent studies of tools, materials, and process peculiarities. The training of workers figures here, as also the question of wage adjustment and other incentives to effort. There are many ways by which the management may proceed. It may roughly guess in the old-time way, which means "passing the buck" down the line until the last unit, the individual worker, takes the responsibility for methods of production. On the other hand, management may assume its responsibilities and use trained specialists to settle methods of work, in which process it may go so far as to magnify scientific methods with the machine as the ideal, and so lose the coöperation of the worker. Between these two extremes are a multitude of compromises, some one of which is best for each case. The problem is to find that best method.

At no other point in the whole range of administration is it so necessary for management to remember the simple principle that in exercising control it is dealing with the two forms of energy,

mechanical and human. The old-style manager who "passed the buck" down the line was side-stepping his responsibilities. The arbitrary ultra-scientific expert makes the more serious blunder of neglecting the human element. The pity of it is that the term "scientific management" has become associated in the minds of the masses with the latter type of specialist. Could it but be branded on the souls of men everywhere, in all grades of service, that in the scientific control of production forces *all* forces must be considered—that the method of the mechanical extremist is not a science but only a part of one—there would be good prospect of coming rapidly to a mutual recognition of the true scientific management that would mean coöperative action. Then the worker could and would demand his right to an accurate setting of his task and to the training to enable him to produce the maximum with the proper maximum compensation. This sounds like Utopia, but it is a true principle of management.

The third unit in the triparte plan of production is standardized product. Standard labor performance with standard equipment to turn out standard goods constitutes correct production control. This last element is so well recognized that there is no occasion for extended discussion. It is the basis of the other major principles, specialization and mass production. The term does not necessarily stand for the highest grade of quality, but it does stand for uniformity and the establishment of a constant relation with the market.

Specialization and *mass production* cannot be separated in thought in their general aspects. The common aim is to increase the production rate. In the first, effort is directed toward lessening the investment of human energy in proportion to output: in the second, toward lessening the investment in equipment. Again it is the union of the mechanical and human elements in production, which can never be separated.

Specialization makes for efficient operation through subdivision of labor. The worker who executes few movements in the performance of his task becomes expert in those manipulations. His muscles act without conscious effort on the part of the brain, in great part, and in certain processes the centers of reflex action alone serve to coördinate his movements. Even in the more complex series of hand processes, each act serves as a stimulus to which the next is the reaction, response being semi-automatic and occurring with a minimum of directing effort.

This constitutes habit. Under such conditions there is small tendency to fatigue of either brain or muscles. Performance is accurate and rapid, relatively. It is a favorable circumstance, and operating conditions should be so adjusted that both employee and employer benefit from it financially. The employee contributes his physical attributes and muscular power, while capital has provided the equipment and the organization making this personal accomplishment possible. The result is more output, or created wealth.

But speaking broadly of the whole scheme of production, and not of individual cases, there is a limit to the increase of productive power made possible by specialized methods. The practices of earlier days, when workers followed the manufactured article through its successive stages and saw it finished for the use of the purchaser, put into industry something that was worth while and for which present practice does not make direct provision. There is the necessity of providing something that will take the place of the stimulus afforded by former conditions—something to hold up the morale of the working force. It is one of the major problems of management.

It is only when the conditions of mass production prevail that specialization becomes really effective as applied to workers in the class of machine operatives. Competition in the markets of the world can be met only as goods are turned out in such quantities that modern machines may be employed to advantage. This is to say that economic production calls for the use of labor-saving machinery, while it becomes necessary at the same time to employ the machines fairly continuously in order to prevent investment expense from wasting the savings in labor. The plant must be designed for effectiveness in the use of equipment, and then organized for effectiveness in operation, through a control of product that permits of a steady movement of material in quantity proportionate to the capacity. What the designer foresaw the operating manager must maintain through an effective organization of forces.

While many of these points pertain to the general field of administration, it is through organization that effective results are to be secured. The realization of the advantages that may be secured by a proper standardization of processes, brought about through the development of workers made effective by specialization, and by the creative efforts of experts in the various lines,

is dependent upon a far-sighted policy put into effect at the inception of the enterprise. It is easier to build new than it is to tear down faulty structures and build on the ruins. Provision must be made for development on the living organizm theory of industry. This theory is based on the simple proposition that industry is an organism, alive and growing, the parts of which are mutually dependent on each other. Capital, labor, equipment, and the directive mind of management, all have their places and each is a partner and co-worker with all the others. Through correct organization, the growth of the plant along lines of symmetry is provided for.

Classification of Industries. -Before attempting any formulation of doctrine, or rule of action, it is necessary, furthermore, to recognize certain differences among industries. The same yardstick will not apply to all, obviously. Placing the emphasis at one point is all right for one plant but all wrong for another. The various functions of designing, of purchasing and handling of materials, of selecting and ordering the use of equipment, of directing labor, of selling, and of accounting all must be attended to in every case. Where emphasis should be placed-where strong men armed with major authority are most needed—is not so clear.

In any attempt to analyze these differences, the distinctive characteristics of industrial types must be recognized. Practice as exemplified by organization plans of successful enterprises shows a tendency toward certain forms having a relation to production conditions. What these conditions are is revealed by the following classification into four groups:

Group A.—Industries in which the raw material determines the character and, within limits, the quality of the product. That is, while equipment and process and labor are not without effect, in this group of enterprises material plays the major part. Salt refining, ordinary lumber mills, raw sugar mills, and canning and preserving are familiar examples.

Group B.—Industries in which equipment determines the character and quality of the product. Of course, material continues to have influence, as it always will, as also do labor and process steps. But we may distinguish in such activities as shoe manufacturing, milling of patented cereals, pressed metal goods plants, cordage and twine plants, and many others,

conditions wherein labor and materials must be made to accord with the demands of the equipment. Equipment sets the pace as well as quality standards.

Group C.—Industries in which process determines the character and quality of the product. This group shades gradually from the one dominated by equipment, but there are distinctive differences. Two oil refineries may use essentially the same kind of equipment but their products may differ radically. This is the result of placing experts in control—men who know how to control the process. So it is with the coal tar dyes and a host of other chemical industries, including cement, glucose, leather, bakery goods, and steel.

Group D.—Industries in which labor determines the character and quality of the product. Here again there are gradually shaded variations, with some difficulty in seeing just where equipment ceases to control labor and labor begins to control equipment, but in the great majority of manipulative industries the difference is clear. Fabricated articles, whether in steel, in cloth fabrics, in wood, in tobacco, or in leather, represent the group. We have here the demand for high average skill among workers, as distinguished from the demand for a few highly trained directors of process in the preceding group.

When carefully considered, these differences are real. The administrator who has the task of laying out his operating plan and assigning proper men with proper degrees of authority has a difficult task, and there are no set rules that can take the place of sound judgment and common sense. The preceding statement of differences suggests a basis for adjusting degrees of emphasis, however.

The Organic Functions.—In Chapter I there was outlined the process by which the simple elemental or "one-man" industry evolves into a fully developed one. It is there made clear that certain organic functions characterize every producing enterprise: namely, *Control, Design, Equipment, Operation, Material, Sales,* and *Comparison.* These are not artificially chosen divisions of production activities; they are absolutely necessary and ever present functions to be performed, whether one wishes to do so or not, and whether one recognizes them in the act or not. Wherever men work to a common purpose in production, there is control of some sort. Somehow, somewhere, and by someone, the character of product is determined, whether it be the tone of

an organ, the form of a ship, the fineness of fabric, the mechanism of a Liberty motor, or the voltage characteristics of electric current sold over the wire—and this is design. Something is employed in operation as equipment to be selected and maintained. There must be operation. There must be some material used, either direct or in process, and this must be procured in proper amount and kind, representing the purchasing function. Nothing is produced unless it is sold, even if one sells it to himself. Every product is set to some standard, as to quality, amount, cost, market demands, or price, and probably to all, and in inspection and accounting is exercised the function of comparison. There is no escape from any of these seven functions in any form of producing activity, whether one man or seventy performs them. The converse in true also, that every act of administrative control may be classed in one or the other. They are at the basis of every plan of organization, but they need not dictate the physical form.

Process steps, or various natural divisions of the enterprise, may determine the major subdivisions in the organization plan. This may be in any of the following ways:

1. Separated branches, so distinct that building space must be located at points covering so great an area that proper control demands several superintendents or foremen of equal rank performing the same functions. This covers cases where the same processes are being performed in parallel, and also those where successive process steps are being carried on, with material moving from one to the other. It is here assumed that the division is made necessary by the physical condition of widely separated work, and not by the necessity for special qualifications of the division heads. The head of the plate shop in a large shipbuilding plant may need the same abilities as does the head of the shop preparing structural shapes, but two heads are necessary because of the separation of the shops. The same may be true of the foremen of the carding and spinning rooms in a woolen mill, and, similarly, in many other producing activities.

2. Differing types of work calling for division heads possessing specialized knowledge and experience. This is one of the most common conditions. It applies to heads of prominent divisions of large enterprises, occupying offices side by side at company headquarters. In railroad companies it is customary for officials with the rank of vice-president to serve, one in charge of opera-

tion, one on maintenance of way and structures, one on mechanical equipment, one on finance, and one in the legal department. Oil producing companies of large size have heads of divisions for production of oil and gas (these being sometimes separated), for pipe line transportation, for refining, for control of land and leases, for legal work, for finance, for geological work, and for engineering and construction. Thus it comes about that each type of industry has its peculiar needs, calling for men of specialized training and personality to exercise control in the several divisions.

3. Units of product calling for directors of operations. This appears especially in plants the work of which consists of separate orders or contracts, each of which must be handled as a separate job. Shipbuilding concerns commonly have orders for ships each differing from the others, calling for a superintendent of construction in charge of each one. So with bridge and large building construction operations, widely separated locations demanding foremen at the head of organized forces of workers. In many large plants the variety of goods produced calls for separate departments, as a matter of convenience and effective control.

4. The organic functions themselves, in closely organized enterprises, frequently dictate the major elements in organization. This is the most representative as well as logical basis, where none of the foregoing special process demands require duplication. Using the customary titles of officials exercising these functions, we have:

General Manager, exercising control in general over all others.

Superintendent or General Foreman, in charge of operation, with inspectors performing part of the duties under comparison.

Engineer, Chief Draftsman, Chemist, etc., in charge of technical design.

Master Mechanic or Plant Engineer in charge of equipment.

Purchasing Agent and Store Keepers in charge of material, in conference with designers as to kind and with superintendent as to handling in the plant.

Sales Manager, in charge of selling.

Treasurer, Auditor, Chief Accountant, etc., in charge of general record and comparison as a distinct function.

The last six are commonly of equal rank, all subordinate to the first, except as limited size of an enterprise, or distinctive personality of some individual, may cause some one person to

exercise supervision over two or more branches. In certain industries of the continuous process variety, such as flour milling, paper manufacturing, printing and publishing, knit-goods production, etc., it is customary to merge control, operation, and comparison under the one general superintendent with subordinate employees working in the several lines.

A factor that is frequently of great influence in shaping organization plans is that of personality. This is likely to occur when a company develops from small beginnings and individuals of special strength and ability have happened to become associated with the enterprise. It is frequently a source of danger, leading to an illogical plan and interfering with the training of subordinates to take responsibilities. It is an axiom of administration that no single individual should become indispensable in an organization. Every plan should be thought out with care, keeping this idea in view along with the principle of developing responsibility in a line of subordinates. Consistent policies in promotions are necessary adjuncts to the last mentioned phase. Nothing is more detrimental to morale than to have a vacancy at the head of one department filled by the process of extending the duties of the head of some other department so that the latter person takes over the work. It is a blow to departmental pride that more than offsets any likely saving in salary, provided the original plan was well developed at the start. It suggests favoritism and breeds suspicion.

Coördinating Agencies. Up to this point the discussion has been along the line of departmentalizing the enterprise. This tends toward the attainment of all of the five objects listed at the opening of this chapter under *aims*, except the first two; namely, to systematize operations and to secure coördination of effort. The building up of departmental morale is of prime importance, but, after all, the main purpose is to stimulate production, and this is a function of the entire establishment. There must be coördination and centralized control. The organization plan must provide for this.

There are various means by which this general object is attained. In certain types of industries, notably in metal manufactures in self-contained plants, the planning department has become a feature. The function of this branch is to analyze orders, arrange the sequence of operations with a view to expediting work that calls for fixed time of delivery, plan movement

of material so that finished parts arrive at the proper times at the assembly floor, prepare such instructions as may be necessary, maintain a follow-up system, and perform such other service as the special nature of the work may demand. It is the nerve system through which the general management keeps in touch with operations. How it ties into the organization will be seen later.

The group conference of divisional heads is another measure for coördination. In the main its aim is to determine policies, but it may go farther into details on many points having to do with types of product (design) and phases of operation. The conference must not be left to chance or to the whims and personal convenience of the executive head. Its duties and functions are matters to be defined clearly, as also the times of meeting. If systematic procedure is expected in the plant it must be effective in the office.

From the conference of executives it is but a step to the shop committee. There are many questions that are mutual and vital to the interests of employer, employees, and to the success of the enterprise. The mutuality of interests calls for coöperative control, consisting of a genuine sharing of the powers of management. This is not granted through the beneficence of the employer, but is a means for maintaining a successful business. Naturally, all phases of personnel administration come within the scope of this committee's duties, and this covers many of the most vital matters touching the welfare of the plant. There is no form of industry to which it may not be applied with beneficial results, provided there is the real desire to establish a coöperative basis. The forms taken and the questions coming before it differ greatly, of course, among the many types of plants, but there is no industrial enterprise in the world that does not have its problems in the adjustment of working conditions, selection and training of employees, social and personal welfare, whether recognized or not, and the all-important matter of compensation of labor. All such are within the range of action of some group in which both parties are represented in a free and open manner, and which meets on a regularly established basis. Its findings, while not necessarily final, must have a definite status assigned in the scheme of control. This must be on a dignified and significant plane, so that serious consideration of matters may be assured. Men develop the practice of serious

thought as occasion makes its demand. There must be some authority vested in this group, else its meetings are farcical, and with authority there must go responsibility. These two functions can never be separated.

Divisional Organization.—In certain classes of enterprises where operations extend over large geographical areas, the need for coördination and centralized control has developed a form of secondary organization which makes each geographical division more of a unit than would otherwise obtain. The best illustration of this in private industry is the railroad. In each territorial division there are employees from each of the main departments of the central organization, notably trainmen, yardmen, maintenance-of-way men, dispatchers, and engine and roundhouse men. Each of these groups must operate according to plans and methods established at the head offices of their respective departments. Under the plan that has characterized railroad administration from the earlier days, now called the "departmental" plan, the division superintendent exercises control over only those groups engaged directly in the operation of trains, namely, trainmen, yardmen, and dispatchers. He can secure coöperation authoritatively with the other groups only by referring back to his main department head, who confers with the heads of the other departments for the issuance of instructions down those other lines of control to their men in the division.

Of course the unofficial coöperation that men working side by side in the division naturally adopt enables the superintendent, division engineer, and master mechanic to operate harmoniously, and lessens the inconvenience of remote control along parallel lines, but enough of difficulty has been encountered to lead some roads to adopt what is called the "divisional" form of organization. By this plan the entire divisional force is placed under the operating orders of the superintendent, the separate groups looking to their departmental chiefs only for general instructions as to methods and standards peculiar to their own lines of work. (For full discussion of this plan see Morris' "Railroad Administration.") A similar plan has been adopted by petroleum producing companies whose operations extend over large areas.

Military Organization.—This discussion would not be complete without reference to modern military organization for armies on a field basis. Many writers on industrial organization have

referred to certain types as being "military" in form, but in so doing they have in mind an ancient form, rigid and inflexible in character, and entirely unrepresentative of actual conditions in the military service today.

In modern army organization, the operating basic unit is the division, within which are various types of subordinate units, each trained for a special service. For the direct purposes of control in operations, all are under the immediate orders of the division commander; but for certain standards, such as training for specialized work, and in the development of equipment, each special service unit looks to its chief of service at general headquarters for direction and support. It is a logical plan, similar to the divisional plan in railroad administration mentioned in the preceding section, and is entirely consistent with the best thought in industrial organization.

Organization Charts.— In considering forms of working organizations, distinction should be made between line and staff types. The first is referred to by many writers as being of military form, as noted in the preceding paragraph, although the reference to the army plan presupposes a form now obsolete. The distinguishing characteristic is a direct line of responsibility from the active manager down through the several grades of superintendent, assistant superintendent in charge of operating branches, foremen in charge of sections of the plant devoted to special lines of work, and gang bosses. Alongside the superintendent in charge of operation are the various heads of designing, purchasing, sales, and accounting divisions. The line of authority is distinct, the principal difficulty encountered under modern methods arising from the fact that each intermediate member in the chain of officers is compelled to exercise the several functions of control, setting the conditions of labor, determining standard practice, and directing the general conduct of affairs within his sphere of influence. In other words, each officer is called upon to exercise administrative and legislative functions at the same time. The benefits of specialization are not realized. It is reasonably well suited to those conditions of production that may be described under the name of construction rather than of manufacturing.

The staff type has as its distinguishing characteristic the recognition of specialists who are assigned to the task of setting the conditions under which work should be performed. It is some-

times referred to as "functional" organization, where the term implies the exercise of distinct authority over methods employed in the performance of definite portions of the work. It is com-

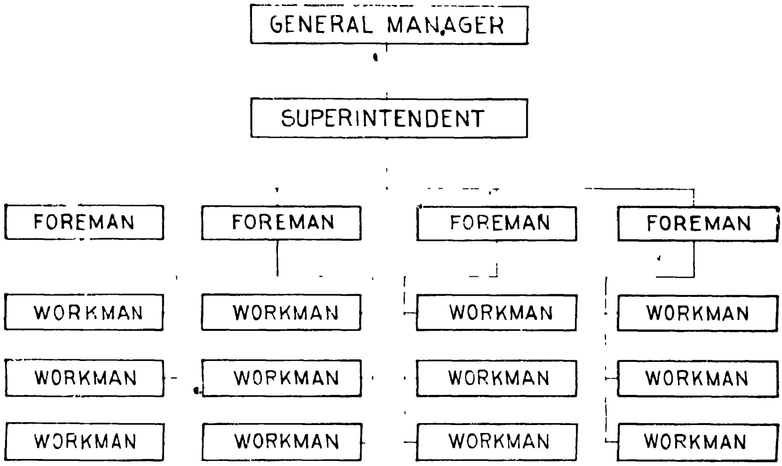

FIG. 11.—Line type of organization.

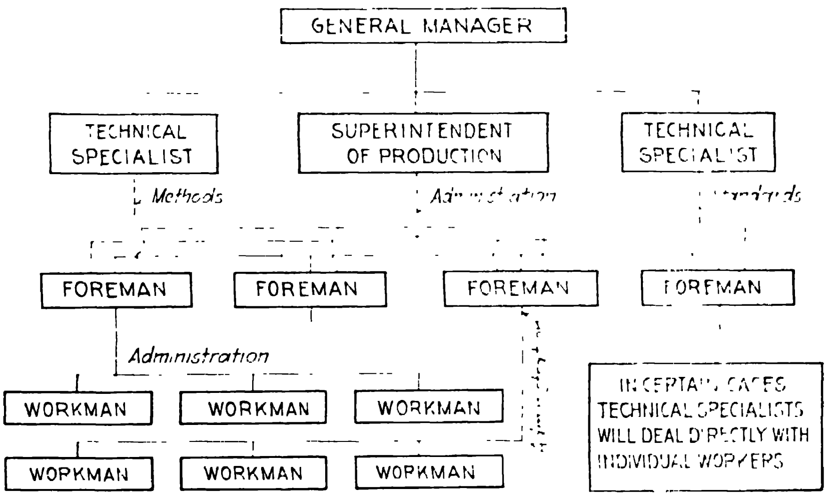

FIG. 12.—Staff or functional type of organization.

monly represented on the chart by the planning department, which is composed of persons who are specialists in their several divisions. This general plan is applicable, in the main, to concerns where true manufacturing under the conditions of standard-

ization and mass production are being realized. The seeming criticism coming from the exercise of control by several different directing heads over workers is less significant than at first appears, when the system is properly developed. A combination of line and staff types constitutes a third classification and possesses most of the advantages of both of the pure systems. It retains in all essential respects the advantages that come from the specialization made possible under the staff system.

The accompanying diagrams illustrate the first two types in conventional form. Following these are other charts which show actual practice in existing organizations and bring out the features of the combined line and staff type.

Referring again to the classification of industries outlined in a preceding section, it is to be noted that the four dominating agencies are raw materials, equipment, process, and labor. The illustrations which follow, and which are taken from actual operating plants, are chosed to represent these four groups. They are as follows:

1. Woolen manufactures to the yarn stage only, wherein standardized methods are employed, representing the case where the quality of material fixes character of product.
2. Shoe manufacturing, wherein equipment determines types, styles, etc., labor in this industry being to a large degree devoted to machine operation.
3. Oil refining, wherein process control is the adaptable factor, equipment being operated under the limitations imposed by process demands.
4. Two typical metal goods manufacturing plants turning out standardized products.

The accompanying diagrams present these main features of organization. Some study is necessary to detect the differences in emphasis on the four elements, especially among the last three. In fact, the differences may not be observable except as one goes beyond what is specified in the diagrams and notes the differing relationships of worker to equipment and product.

In woolen spinning the main problem is to keep the material moving to, through, and away from the standardized machines. At one point only does the worker influence the character of product materially, and this is in the process of mixing the wool. In this step there is no machine at all, other than for transportation.

In both (1) and (2) the machines dominate the workers. The chief difference between them is that in No. 2 the material is cut and adapted to the machine and different materials may be worked, while spinning machines are adapted to the wool. Number 2 calls for a more complex business organization because of the multiplicity of forms of product as well as of kinds of material employed. Cost accounting and production records call especially for attention, the distribution of expense being much more complicated. In this respect Nos. 3 and 4 correspond to the second.

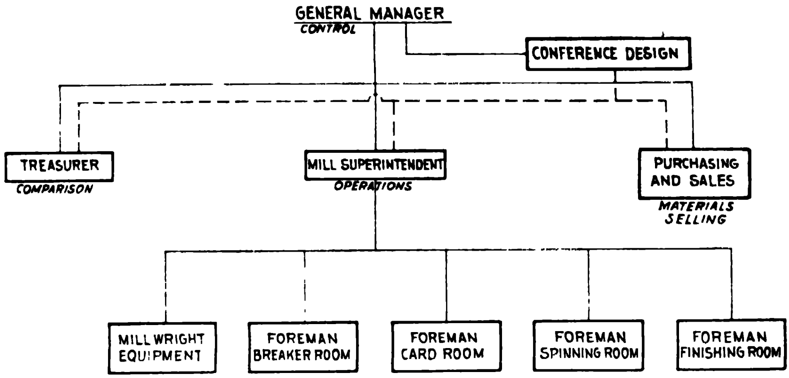

FIG. 13.—Organization of a woolen mill.

In the industries represented by oil refining and metal manufactures the workers dominate equipment. They differ from each other in the fact that in No. 3 the workers manipulate the apparatus in accordance with the instructions of technicians who control the process, or who detect the chemical reactions vital in the process, while in the last group the personal skill of the workers is the basic element on which the production manager depends for results. In the chemical industries, therefore, the technical superintendent, himself a chemist, occupies a leading position. But in general manufactures, be it in leather, metal, or wood, it develops that business and executive abilities combined with knowledge of the product are the factors which are most prominent in the control of operations. In the last group, therefore, we see the planning department as the systematizing agent in its most complete development.

Organization Axioms.—In the light of the foregoing discussion one may now inquire as to how the organization of an enterprise

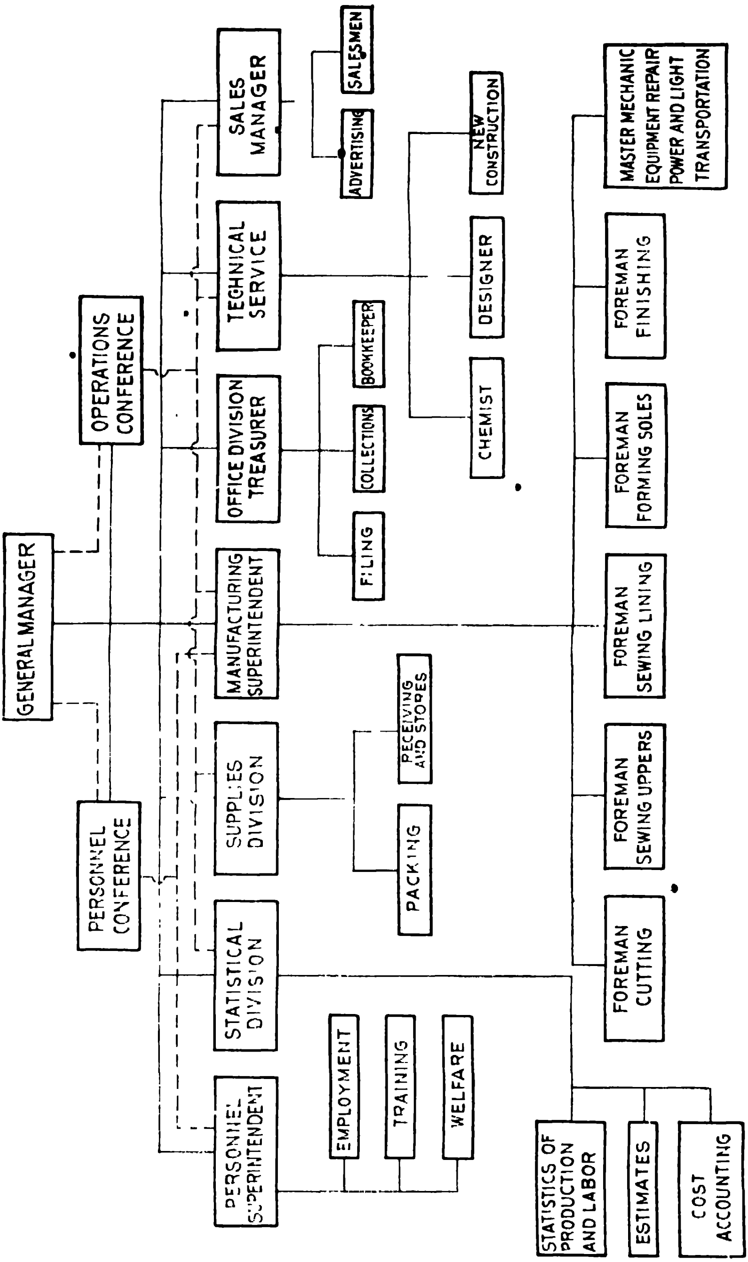

FIG. 14.—Organization of a shoe factory.

shall be determined. The exact steps by which he shall proceed while the enterprise is in the formative stage are not always clear to see. The position of an administrator who is laying out a new plan is one in which there is an insistent demand for judgment and a clear perception of operating needs. We have seen how various types of industries are organized, but this in itself

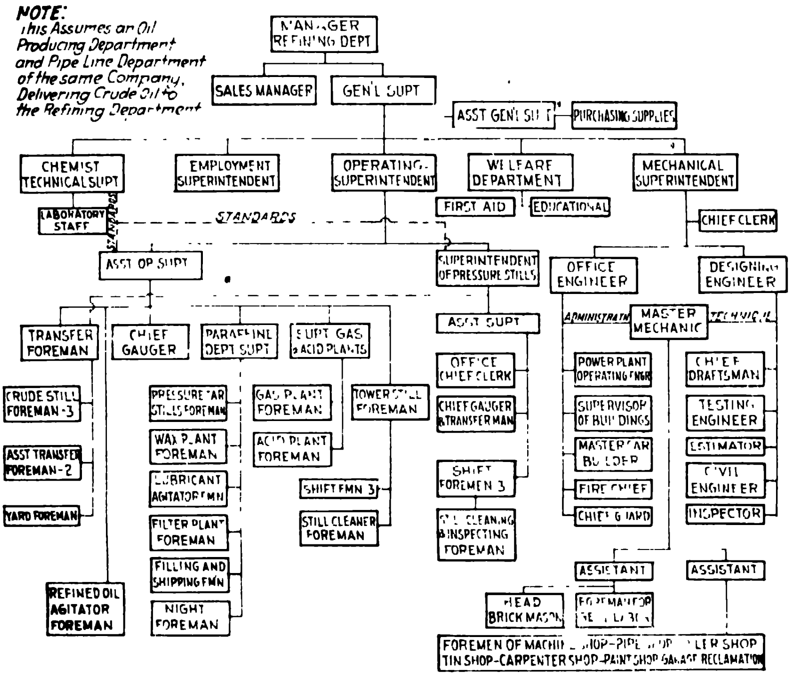

FIG. 15.—Organization of the *Blank* Oil Refining Company

does not always furnish a pattern to which one may safely cut in fixing on the details for a new enterprise. The man who has this responsibility must work carefully, studying in detail the peculiar needs of the particular business that is his to deal with. There are no absolute rules for procedure. Cut-and-dried formulas are impossible. Every enterprise has its own peculiarities so that judgment and a keen business sense are necessary. The following seven principles or axioms are offered as guiding thoughts for anyone who has this task to perform.

1. *The Motives of the Administration Are Bound to be Reflected in the Organization Plan.*—It has been said that any company

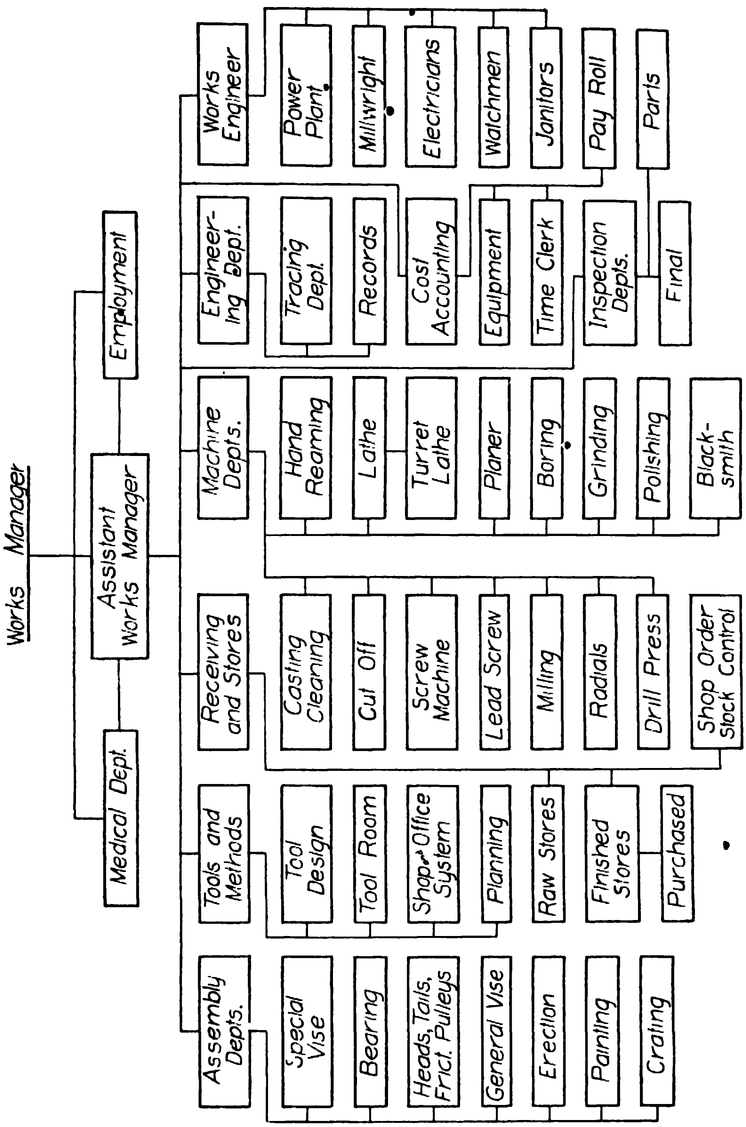

FIG. 16.—Organization of a machine tool manufacturing plant.

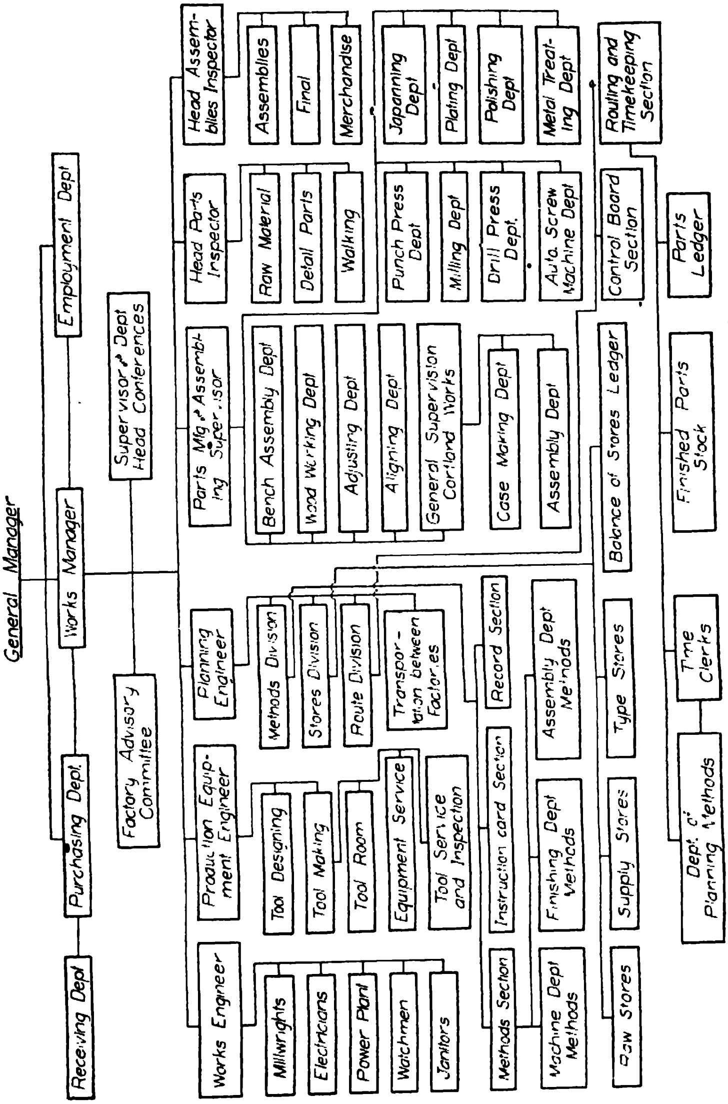

FIG. 17.—Organization of the *Blank* Typewriter Company.

desiring to establish coöperative relationships with labor can do so if the desire is sincere. The personal characteristics of the administrative head will be manifested, not alone as to this matter of attitude toward labor but in many other ways as well. The use of technical specialists, the emphasis to be given to marketing, policy as to departmental relationships—all are matters which, in their adjustment under the scheme, will reveal controlling motives.

2. *Emphasize the Dominant Element in Production.*—Whether it be material, equipment, process, or labor, the plan should be so adjusted that the individual who must take the first responsibility for the element in question shall be in his proper relative position. It may be that several demands will call for similar treatment, in which case the purpose will be attained when these have been given recognition on an equal basis. One need not shrink from giving an expert the control over process, for example, even though his administrative control is limited to the small number of men in his own laboratory.

3. *Authority and Responsibility Must Go Hand-in-hand.*—This is the most fundamental statement in the list, but it needs continued repetition because it is continually neglected. Instances without number may be observed where operating officials have been forced to take responsibility without having been granted the proper authority, and many others in which ambitious persons have acquired a measure of authority inconsistent with the responsibilities which they are willing or able to assume.

What is necessary is that every executive shall have freedom of control in matters of procedure, within the scope of the general policy established by the central administration. Difficulty is frequently encountered in fixing the authority of the operating department head in relation to the duties of others in charge of equipment and plant service. It is not possible to announce any one plan applicable to all kinds of enterprises, but it is essential that the question be thought through to a conclusion and a definite plan established. It is clear that where there are several operating departments of equal rank, and efficiency demands a service department, the general management must reach farther into the organization.

This touches the heart of organization. In large enterprises with varied activities, there is always the tendency to build up

duplicate organizations. We have in mind a large petroleum company with operating departments in the distinct branches of oil production, natural gas production and distribution, oil pipe line transportation, refining, and casing-head gasoline extraction. Each of the five main operating divisions has large amounts of construction work to be done, spread over large areas. In several, construction subdepartments had been developed, while a central construction department performs the work for the others. The question, in such a situation, is whether the placing of all construction under the one service department would take away from the heads of the main operating departments so much of control as to interfere with the carrying on of work essential at critical times and places. This serves to illustrate the care necessary in adjusting degrees of authority to be vested in responsible heads of operating divisions. Theory might teach concentration of similar work, like the construction work just referred to, under one service department, but the loss coming from failure to articulate in a single instance might offset the economies of concentration.

Another case in point is that of divisional organization of railroads, for the purpose of coördinating service on detached divisions. Carefully drawn instructions are always necessary under the plan of control that carries authority to one official to say *when* and *where* work is to be done, and technical control to another official to say *how* it shall be done. It is not an easy adjustment to be made, but the manager who is looking for ease in such matters would do better in some other business. Many a situation has become tangled because the manager with authority side-stepped his responsibility for issuing definitely worked-out instructions. Good organization may not mean an easy ascent to efficiency levels, but it does mean the providing of the necessary driving power to carry the enterprise up the grade.

4. *Distinguish between Personnel Control and Operating Technique.*—In industries of Class 4 (see page 231), where labor predominates, methods of work may be designated by persons other than those holding administrative control over the time, pay, and general working conditions. This is a case of divided authority, apparently. It sounds like a bad situation, which it sometimes is. It all depends upon the fairness with which the operating plan has been developed, as well as upon the wisdom and executive capacity of the foremen who are involved in the

double function. There is danger that the plan will be but partially worked out, extended far enough to create the difficulty but not far enough to produce the antidote.

5. *Don't Make Places for Men.*—The evils resulting from placing favored persons in responsible positions are so obvious as to need no comment. A corollary almost deserving separate mention is, "When a place exists don't hesitate to put a man in it." Giving one man two jobs may possibly mean an economy for a time, but it is not likely that a successor is developing who can assume the double duty, and it tends to make the first man indispensable. A second objection is that it is bad for morale in the department. The road of advancement to the headship is blocked in at least one of the departments.

6. *Make All Organization Assignments Definite.*—Every plan should be built upon a carefully studied outline of operating procedure. Drawing a line diagram does not complete an organization, although it is a help. Fully detailed instructions as to the operating plan and the part taken by each official, with limitations clearly designated, are necessary. In certain types of organizations, where it might be obligatory to enter into enterprises where mistakes would be disastrous, the study of processes, and even rehearsals, are essential phases of the plan, in order to make sure of harmonious coöperation. This lesson was learned in preparing for military operations during the late war, and there is something in it that is worthy of the thought of men concerned with important industrial enterprises.

7. *Be Fair.*—The trend of modern times is toward a relationship in industry that recognizes the partnership basis as the basis promising the most secure and permanent success. On this subject a volume should be written. It calls for organized methods for bringing together the representatives of both capital and labor for frank and free discussions of questions at issue. Beyond this there may be such provisions for joint action as policy and controlling motives may dictate. Labor is past the stage where it can be fooled, and the policy of writing into the organization plan a frank and full statement of methods to be followed in the adjustment of industrial relations is the only method that will stand the test of time. No particular scheme is advocated here, but the more arbitrary, but fully understood, practice of the past is better than any makeshift method patterned imperfectly after the more modern practice.

CHAPTER X

ORGANIZATION AND MANAGEMENT

B -Operating Methods

In the preceding chapter the framework of organization has been dealt with from the standpoint of the general executive concerned with the creation of a staff that may function under defined limits of authority and responsibility. There remains the task of developing a plan of operation, under which the many functions of administration may be performed.

In the actual process of organizing an industry, the analysis of these operating functions, here assigned to second place in discussion, must be carried out first. One needs to decide just how orders are to be transmitted, who is responsible for originating plans, which of the several department heads must unite in action in carrying out those plans, in what ways line and staff officials are to unite in the control of operations, how workers are to be selected and trained and their welfare attended to, and how the various steps in control of materials, equipment, and product are to be directed, before he can construct the organization chart. It is apparent that the stereotyped form of chart, of the kind shown in the preceding chapter, does not show actual ways of doing business. The lines which connect the figures representing officials in the organization are lines of authority, not of actual functioning. They appear to indicate paths of action up and down the several divisions, as though it were impossible to cut across for purposes of comparison and coördination It is not possible, on such charts, to show the cross lines of contact that are essential to effective functioning. The actual duties of the directing heads of groups and departments are not indicated at all.

However simple the question at issue may be, persons in different parts of the plant are concerned with it. It may be a bit of steel to replace a worn part on a repair job. The workman

on the job asks his foreman for an order on the stock room. In supplying the material there will arise questions of quality for the designer; questions of purchase if special quality is demanded; stockroom records; methods of work in machining the article and giving it the necessary heat treatment; timekeeper's records; cost accounting; inspecting, and final assembly. It must be decided who is the one to originate the order—whether the machinist actually on the job, whose time will be diverted from his task while questions of kind and supply are being settled, or a clerk from the order of work office, or a member of the designing staff; what route the order for material shall follow; who shall inspect the work, and when; who shall select the tools to be used; by whom the records shall be kept. Or it may be the development of a new class of product—a new style of shoe, a brand of paper, an improvement in an automobile motor, a new type of steam turbine. The suggestion for improvement may come from the salesman on the road, from a workman in the shop who has seen a chance for better construction, from a designer or chemist, or from the chief executive himself. Who shall develop the idea; what department heads should be in conference; how extended shall be the experimentation; how shall the development costs be distributed; how authoritative may be the decisions from conference of designer and purchasing agent on available materials and market prices? Every significant step in the process work calls for the exercise of some sort of action by an individual in the organization, which action bears upon some other individual in the exercise of his duties. Smooth running of the producing machine demands that such contacts be provided for. To do this is to lay out the plan of management, for which the organization is to be adapted.

In addition to these matters of operating technique are other phases of administration. The successful handling of personnel calls for definite planning. Policies for hiring, assignment to the various classes of work, training, maintenance of personal records, health and sanitation matters, social and living conditions, must be established. A plan of wage adjustment is to be determined upon and provision made in the organization for carrying it out consistently. Some of these questions have been considered in a general way in the preceding chapter, but now the actual operating program is to be settled upon.

MANAGEMENT FUNDAMENTALS

Modern management methods are a natural outgrowth of the general advance in industry which has taken place since the advent of the steam engine and the power spinning frame and loom. Those early developments marked the beginning of a type of transference of emphasis from human energy and skill to labor-saving equipment, which has advanced steadily through many stages. The habit of studying the possibilities of advancement in method became fixed. At first the planning of improvements was confined largely to mechanical elements. From there the work passed gradually into the finer stages of apparatus perfected to secure effective adjustment of process to product, and finally to the task of coördinating the entire mechanism of production through the control of all the factors. The personal skill of workers in handicraft has been transferred to manipulative dexterity, while the range of management has extended to cover the human problem of coördination. This means that those exercising executive control have applied designing skill in adapting the movement of material and attendant labor to refined equipment, so as to secure efficiency of the higher and more complete sort. It has demanded consistent planning based on a study of all of the factors, material and human, which affect economic production.

The outcome has been the throwing of responsibility on that part of the managing staff that has to do with the details of operation. A realization of this fact came when it was demonstrated that careful planning of work schedules and scientifically conducted studies of methods of doing work yielded notable results in increasing production and reducing costs. It was heralded as a new departure, when in reality it was only a developing phase of modern industry, which had been advancing steadily through the transference of skill of workers to successive agencies in the producing mechanism. Rather than apply any coined phrase like "scientific management" it is better to recognize in it the application to management of the same constructive skill which had characterized advancement in other lines.

The primary fundamental in management is, therefore, consistent planning according to methods of scientific analysis. This means that every factor is to be taken into account. In the words of the report of the Committee on Administration of the American Society of Mechanical Engineers, presented in 1912,

"The prominent element in present-day industrial management is the mental attitude that consciously applies the transference of skill to all the activities of industry."

In the same report this committee goes on to say: "The regulative principle of management along scientific lines includes four important elements:

a. Planning of the processes and operations in detail by a special department organized for that purpose.

b. Functional organization by which each man superintending the workmen is responsible for a single line of effort. This is distinctly opposed to the older type of organization where every man in the management is given a combination of executive, legislative, and judicial functions.

c. Training the worker so as to require him to do each job in what has been found to be the best method of operation.

d. Equable payment of the workers, based on quantity and quality of output of each individual. This involves scientific analysis of each operation to determine the proper time that should be required for its accomplishment and also high payment for the worker who attains the standard."

A carefully prepared article[1] appearing at about the same time carries a somewhat more terse statement of the principles of management, as being:

1. The systematic use of experience, the instrument of which is *comparison*.
2. The economic control of effort, which is experience in action.
3. The promotion of personal effectiveness, the conditions of which are:

The individual worker must feel leadership.
He must have adequate encouragement and reward.
He must be physically fit.
He must work under good physical surroundings.
He must receive a definite allotment of responsibility.

These two statements unite in emphasizing two distinctive points. One pertains to organization type, to the effect that provision should be made for functionalizing executive control to

[1] By Church and Alford, in *American Machinist*, May 30, 1912.

secure the advantages of standardization and specialization; also to provide for systematic planning of operating methods. The other is a matter of motive and policy in attending to human needs in accordance with the mandates of justice.

In the years which have intervened since the attention of industrial executives was turned toward advanced methods of management, various doctrines have run their courses. In this, as in other phases of human endeavor, the doctrinaire has come forward with his theories and then given way to a more sane standard. The advocate of system pinned his faith to numerous accounting and regulative schemes wherein muti-colored cards and forms held conspicuous place. To such, it appeared that with a sufficient number of counts and checks the industry would run smoothly with the current. They overlooked the rocks lying just below the surface. Following those, there arose the advocates of an independent personnel department, who saw in a specialized treatment of the worker the solution of human ills in industry. But in a rather notable abandonment of the personnel department in recent years it has seemed that opinion has come to view, with a considerable measure of suspicion, the uncoördinated activities of a group of specialists whose interests are other than the producing power of the plant. This does not argue that the interests of workers are held in less esteem, but rather that problems of personnel are a part of management not to be separated too widely from the executive control of production.

The difficulty with these specifics in the hands of their devotees is that they are substitutes for true human leadership. Real advance in the art of management comes from an adjustment of the mental attitude of industrial executives toward the combination of material and human factors in production, rather than from the addition of new agencies. This attitude has been developed in many places, and properly coördinated methods of dealing with personnel problems retain their standing. As one prominent industrialist[1] has recently said: "It may be mentioned in this connection that the results accomplished through the work of our employment, medical, and safety departments have been most gratifying through reduction of labor turnover and the conservation of health and human life among the employees, and

[1] EUGENE G. GRACE, President of Bethlehem Steel Company, in *Personnel*, May–June issue, 1921.

we aim constantly to go forward in this work to the end that our plants may furnish safe, healthful, and amicable employment."

Another[1] says: "We have found that it pays, and pays well, in mutual satisfaction and production, to give as much and as close attention to the human as to the material side of industry."

Alongside of *scientific planning* there is now placed *leadership*, the two standing as the primary fundamentals in management.

This statement of principles and policies forms the groundwork for an analysis of the detailed steps to be followed in organizing an enterprise for successful operation. Absolute rules cannot be laid down to fit all the varying natures of undertakings in the industrial field, but the more outstanding may be outlined. In part, the analysis may serve as a basis for setting up correct combinations of administrative units in a formal organization scheme, but more particularly it will deal with the functioning of members of the management staff whose positions are the well-recognized ones in standard organizations.

MANAGEMENT UNITS

The Manager.—The man exercising active control over the organization is the center of a group whose duties extend far into the plant. His relations with those who share the responsibilities of control over men, material, and process, form an index of the plan of operation of subordinate groups. Three classes of functions are performed by the manager. Through relations with the officers and board of directors of the company, he deals with matters of general policy. He may be an official in that group, or he may be an employed executive. It is unnecessary to enlarge upon the questions decided here, pertaining to general finance, policy on market extensions, expansion of business, etc., other than to call attention to the division of the field of finance. The responsible finance officer, or treasurer, of the company functions in this directing group, controlling matters of investment, credit, and company securities, while matters of operating finance having to do with normal receipts and expenditures in the conduct of business are attended to under the executive control of the manager. If the same director of finance is in charge of both functions it means that he acts in a dual capacity,

[1] HAROLD S. MCCORMICK, President of the International Harvester Company.

part of the time in the directing group and part of the time under the orders of the manager.

The second function of the manager is as an executive, in which he issues orders to department heads in the operating organization. This is the exercise of authority of the line, through which the machinery of production is set in motion. The heads of the departments constitute an official family, frequently organized definitely as a committee to handle various

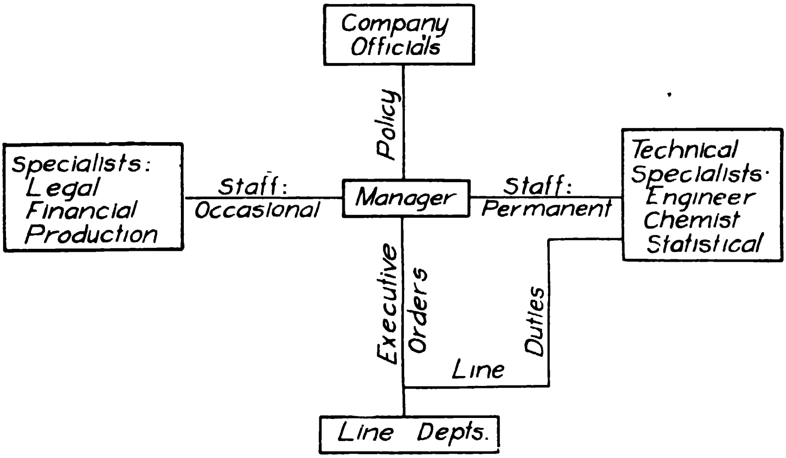

FIG. 18.—The manager unit.

administrative questions. This does not refer to what is known technically as the "shop committee" plan, but merely to conference groups of executives.

The third phase of the manager's connections has to do with technical matters of procedure, design of product, specialized practices, legal guidance, and the like. It represents staff organization. Functional specialists are engaged, as occasion demands or on permanent basis according as the continuity of service may dictate. Lines frequently represented are statistical specialists, designing engineers, chemical specialists, scientists in such lines as geology, production experts, and legal counsel. Representative companies differ as to where these staff officers connect with the organization scheme. In some they are on the same level of authority with the heads of operating departments, and in others they are shown with a superior relation to the general manager. The designing engineer and the chemical superintendent in charge of process have, of necessity, relations

in routine procedure with the operating department, and at the same time a special relation to the manager on distinctive questions as to types of product.

The Operations Unit.—This covers the activities of the several groups of workers engaged on the actual work of production. All staff or functional service departments have purposes tributary to this, since here the real work for which the company exists is going on. A better term for it might be the production department, were it not that this name has, through custom, become associated with the functional planning and process study work which is subordinate to operations.

The head of the unit is the plant superintendent (sometimes bearing some other title) who has direct line authority over the heads of the several operating branches. Under earlier line type organizations he, with his assistants, performed many of the functions which have since been delegated to independent departments. He attended to matters of labor, hiring his men, training them, setting their wage rates; determined methods of doing the work, wherein the workers themselves in the skilled branches took much of the initiative; selected and repaired tools and producing equipment, again in conjunction with the skilled workers who took care of their own machines; and distributed material, usually under a system where foremen of working groups requisitioned directly on the stockroom, and little organized attention was given to checking use or waste of the stock. In many of the smaller shops today this condition prevails with good results. The trouble with this system is that superintendent and foremen are required to perform so many and diverse functions that it becomes impossible in the more complex operations.

In the evolution of management, the assistant superintendents were assigned specialized duties along functional lines, and finally became responsible heads of separated departments, responsible to the manager on direct lines of authority but still on a coöperative basis with the operating line forces under the superintendent. There are, therefore, many cross lines of functional activity between groups and individuals in the operations department, and the clerks and specialist process men in the planning department, employment department, stock and tool rooms, service department in matters of maintenance of producing equipment, and materials handling force. The planning

department has charge of so many of these activities which have been brought to a functional basis that it is often carried under the control of the superintendent. In fact it is sometimes provided that the superintendent transmit his orders through the planning-room agents, in which case the planning department is given a more complete organization. It occupies so important a place that it will be discussed separately as a management unit.

Further comment is necessary respecting control of the tool room in metal manufacturing plants. In the last paragraph the reference to placing the stock and tool rooms under independent control might be misinterpreted.

Production of machinery products must be thought of under two distinct classifications. They are sometimes referred to as *building* and *manufacturing*. The distinction is that the first does not employ mass production methods while the second does. In the first, while product may or may not be standardized, production methods are not, unless it be in certain of the smaller parts. Engine building falls in this class. In the second, both product and methods are standardized, and equipment controls the routine operations of workers in major part. The manufacture of typewriters, automobiles, drop-forged tools, and many other specialized products falls in this class.

The proper place for the tool room in the first of these two classes is in a subdepartment under the plant superintendent. This subdepartment may be highly organized if conditions warrant it, with a shop engineer of the planning department responsible for the designing of tools for special work, and with a system in operation whereby tools for different jobs are made up in lots and delivered at the workmen's machines coincidently with the arrival of material, so that neither workmen nor operations foreman has the authority of selection, but still it is proper that the superintendent should have administrative control of the tool room activities. But in the second class of plant it is frequently advantageous to have a producing machine-service department with specialists who set up and adjust dies, cutters, and the like, for successive operations, and have independent control of all forms of tools. This plan is shown on the chart for a typewriter concern in the preceding chapter.

The control of materials brings complications in the assignment of limits in authority. There are three steps involved—namely, purchasing, storing and issuing the raw stock, and storage of

finished parts preliminary to assembly. The last is of significance in the manufacturing of standardized products by mass production methods. By common consent the purchasing agent is in the first line of officials reporting to the general manager, but where his control of the material stops is not so well settled in practice. The storekeeper in charge of raw materials stands in a joint relationship to the operations head and to the purchasing

MAX ______ ARTICLE ______
MIN ______ UNIT ______ SIZE ______ LOCATION ______

ORDERED			RECEIVED			APPORTIONED			USED			BAL AVAILABLE	
DATE	ORD NO	QUT'Y	DATE	PRICE	QUT'Y	DATE	ORDER NO	QUT'Y	DATE	ORDER NO	QUT'Y	DATE	QUT'Y

FIG. 19.—Stock room record

agent. Where there is active control of materials issue and follow-up, as also of records, through the planning department under operations, the relationship with that department is stronger than with the purchasing department. Under other conditions it may be more logical to hold stores with purchasing. Another test is on the matter of originating purchase requisitions. If requirements vary under specifications prepared by the design department for non-standardized product, storekeeper's requisitions should pass through the operations department for approval, but on standard production basis the storekeeper may requisition directly on purchasing agent to maintain stocks at predetermined quantities. Control of stockroom must be established in accordance with these conditions.

The finished parts storeroom must be under the control of the operations department, but should be organized separately from any of the operations subdepartments. The storekeeper requisitions the appropriate manufacturing divisions for parts as required to maintain the authorized number in stock. In smaller establishments where the raw materials stores are under operations organization, both stockrooms may be under the same head.

The inspection service should be a separately organized subdepartment under either operations or production-control department. It includes process inspection of parts, final inspection, and tests of product. Routine testing of materials may be

included. Under the three-line form of organization shown below, the inspection division belongs in the second line, reporting to the general superintendent. Under the two-line form it should be in line with the subdepartments, reporting to the superintendent, excepting in cases where the final test of product assumes important place, which then calls for the head of the service to report

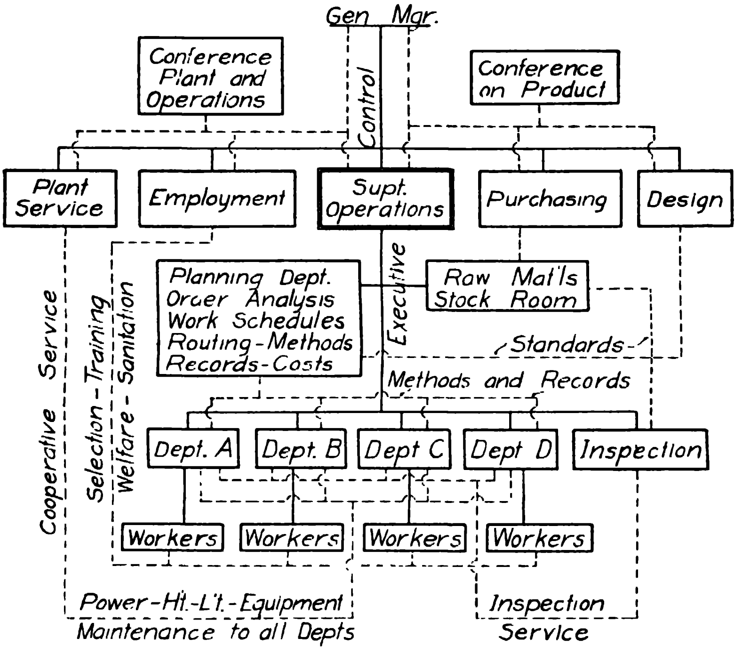

FIG. 20.—Operations Unit two-line type.

to the manager. The inspection service must be in coöperative touch at all times with each operations subdepartment, and with raw materials and finished parts stockrooms. It will also have regulative contact with the designing department and with the shop engineer for advice on standards.

There is apparent a certain incongruity arising from placing service departments such as employment, plant engineering, and operating records on a level with finance, purchasing, and sales, but it has seemed necessary to do this in the evolutionary process of relieving the superintendent of operations from the excessive multiplicity of duties which were his under the simpler forms of the past. The situation is relieved, however, by introducing an intermediate group of departments and forming the *three-line*

type. This is shown in the second unit chart below. It gives a more logical distribution of control, the only disadvantage being that it introduces another general official between the producing branches and the general manager. Probably the disadvantage is more apparent than real, however, since in the larger enterprises there can be but little personal contact even with the *two-line*

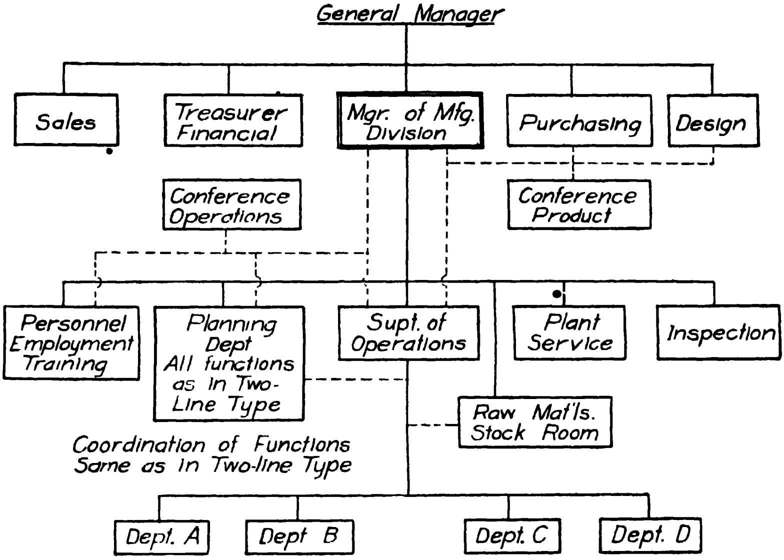

FIG. 21—Operations unit three-line type.

type. In either case managerial control must be with indirect personal knowledge, dependent, that is, on service records rather than on personal contact.

In his book on "Graphic Production Control," C. E. Knoeppel shows on page 382 a line and staff chart which illustrates the three-line type chart given above with certain variations. In that chart he places the receiving and control of all raw material and stores under the planning department, designated by him the production control department. Plant service, designated by him as "power and maintenance," is placed directly under the superintendent of operations. The planning or production control department is shown by him in all cases in position parallel to the superintendent of operation, both being in the direct line of control from the manager of the manufacturing division. In his chart Mr. Knoeppel indicates a somewhat

unusual arrangement whereby purchasing and sales are merged. His placement of the duties of primary costing within the planning or production control department is made on the same basis as that proposed by the author, the accounting department having to do with the more general features and with the permanent records on cost. Readers are referred to the detailed development of organization given by Mr. Knoeppel in his excellent work, which fills a chapter in the volume referred to.

The last paragraphs bring to the front one element which is fundamental in management—namely, personal contact with, or knowledge of, the worker by the chief administrator of the enterprise. At the present-day stage in industrial development there can be but limited personal knowledge. The only substitute for this is records, so made and preserved as to be expressive of the characteristics of the workers, and so graphic that they can be comprehended at a glance by the executive. This is a matter of such importance that it is discussed separately under the personnel department and also under records.

The Planning Department.—While this is a part of the operations unit and has been indicated already in that connection, it is a branch of such great significance that it requires special treatment. In the more fully developed organizations it is the nerve center of the system and the direct means for coördination of effort. Its chief function is to assist the chief executive of the operations unit in retaining genuine control, in this way serving as a remedy for the decentralizing effect that comes from the addition of departments as an enterprise grows. It represents an overhead expense which the small establishment cannot stand, and is justified in larger plants only as it performs a real service in promoting production.

It is not to be thought of as an agency for doing work which would not otherwise be done. Every function performed in the planning department would have to be done by someone somewhere in the establishment. Work must move by some route, good or bad. Methods of doing work are determined by someone, who cannot be doing other work while he is devising the method. The keeping of records is accomplished by some means, even though they may be but the partially formulated sets of facts carried in the head of the superintendent, who must have some basis for determining action as he performs his many duties. The time comes sooner or later in the growth of an

enterprise when the limit of effectiveness of the overloaded superintendent and foremen is reached and assistants to care for specialized duties are needed.

When this time comes, the change need not be a plunge into an elaborately organized department. The functions are divisible so that one group after another may be provided with an inexpensive personnel, until the situation warrants grouping them under a responsible specialist. In the following discussion a full development is assumed.

Just what duties shall be performed in the planning department will depend somewhat on circumstances and the ideas of the general manager. If, when a new unit of this kind is being formed, some branch of the work is being well done in an older operating division it is likely to be left there, even if it be of a kind that might more logically go to the new group. The character of the product makes a difference. Articles built on separate orders make necessary many special studies and the making up of work schedules based on guaranteed delivery dates, which may not be involved in the planning for a plant manufacturing standardized goods in mass quantities to meet a steady market. Any list of functions that may be prepared is sure to meet criticism from those whose experience has been along a specialty line. All that can be done is to indicate a fairly complete list from which any one may eliminate items as he may choose. Furthermore, it is not necessary to call it a planning department. There may be prejudice against the name. A good assistant superintendent with a few helpers will do as well. The important thing is to get the work done.

The head of the planning department may have the title of *Production Manager, Production Engineer, Production Clerk,* or, as noted in the preceding paragraph, may have a non-distinctive term assigned. In a large organization his duties are largely directive, but in all cases they include the preparation of records and reports to show the conditions of operation in a manner that will enable the plant executive to formulate his program. Exact information is required on materials, plant equipment as to condition and utilization, progress on orders, distribution of labor as charged against the several operating and plant divisions, total operating expense, and other details which indicate the situation. This information must be kept up to date. The department head must be familiar with the work of all his special-

ist subordinates, and in smaller establishments will probably perform the routine duties of one or more of them. He is in direct contact with the heads of purchasing, plant service, designing, accounting, and sales departments; with all foremen in the operations department; and is accountable to the superintendent or the head of the manufacturing division.

The shop engineer has a variety of duties in the lines of standard practice, methods, setting standard times on work, task setting, designing of tools and jigs. He has much to do with the toolroom and may be in charge of it. In the development of a planning department he is likely to be the first man on the job and may operate alone as an assistant to the superintendent while the idea of systematic planning is growing in the minds of the management. The important work of preparing standard instructions for jobs and of training workers is under his supervision.

Under the production manager and shop engineer are clerks or assistants who handle such matters as:

Analysis of orders in a plant doing special order work.
Preparing work schedules to regulate progress on jobs.
Routing of work through the shop.
Supervision of material handling, checking waste, and follow-up.
Time-keeping on men and machines, and preparing graphic records of same.
Cost analysis and distribution; sometimes including the complete task of cost accounting.

In those functions of the planning room force pertaining to time keeping and costs, close relations with the accounts branch of the financial department are necessary. Actual cost-keeping may be performed in either office, according to circumstances, but good liaison service is necessary whichever practice is adopted. Further comment on this point is made in the next chapter devoted to costs.

On the organization chart of the typewriter manufacturing company shown in the preceding chapter, there is an illustration of a planning department having a broad scope in the control of operations. In addition to all of the functions listed above there is that of raw material and finished parts storerooms.

This gives to the planning chief nearly complete control of the manufacturing elements, excepting labor.

The Financial Department Unit.—The division of the field of finance and accounting has been referred to before, when discussing the management unit. It will be assumed that the department is primarily under the control of the general manager,

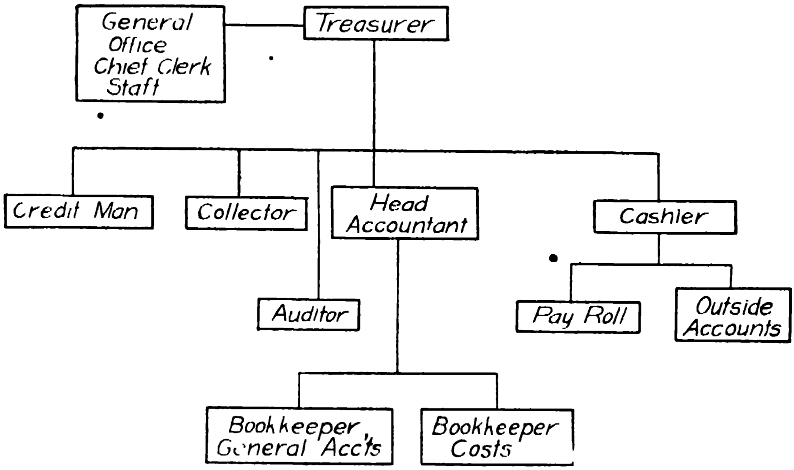

FIG. 22.—The Financial unit.

where routine transactions involving funds must be. The head is taken as the treasurer of the company, who deals personally with credit and company investment problems, with an isolated group of assistants, which phase of his duties is not considered in the unit chart shown above.

There are two branches of the unit. One has to do with the handling of cash and of credit accounts; the other with bookkeeping and records. To the latter branch belongs cost accounting unless that work is performed in the planning department as already discussed. Frequently an accounting department is organized separately, when costs are to be handled.

Extended comment is unnecessary. The chart shown above is expressive of the usual operating organization.

The Sales Department Unit.—In the organization of the sales department, cognizance must be taken of the various marketing methods employed by different companies. Any form suggested as representative can apply only to one type of selling program,

hence care should be taken not to follow it in detail unless conditions correspond.

A concern which sells through wholesale houses or commission agents does not need much of an organization. A shipping department may be more in accord with the requirements. Advertising is of small concern. When sales are made to the retail trade a more extensive force of salesmen is necessary, but even then the department does not require the most complete program. Advertising is conducted through special channels appropriate to the trade. Such goods as are handled in this way do not require technical experts to attend to their adaptation to service conditions. It is when sales are made direct to consumers, with branch sales offices to cover territorial divisions or private sales firms holding agencies for exclusive handling of the product in those divisions, that the most complete sales organization is called for. This condition is the one assumed in the following discussion.

The head of the unit is the sales manager. Prominent in his force are

District sales agents or heads of branch offices.
Head sales engineer, when special machinery is the product.
Advertising manager.
Shipping clerk.
Billing clerk.

The last two named members of the company force are not always under the sales manager. They are frequently on the staff of the accounting department, when that branch is organized seperately from the central financial department. When they are under the sales organization their duties must be closely coördinated with the book keepers in the general offices.

In large machinery companies the selling force is composed mainly of engineers who combine the functions of sales and engineering in the placement of the product. Equipment of that kind must be applied properly to the customer's service, and good engineering judgment is required of the salesman. To place a machine where it is not suited to the needs of the customer is a worse error than to lose a sale. Sound knowledge of the product and ability to interpret specifications and contracts constitute the salesman's stock in trade, rather than a

suave personality and an aptitude for entertainment, which were once considered primary requisites.

The sales manager is responsible for the selling campaign. He formulates plans for selling, opening new territories to the goods, meeting competitors, and advertising. His reports should deal with necessary modifications in design to meet market demands, as well as with market changes likely to affect volume of business. He is an important factor in the progress and prosperity of the enterprise.

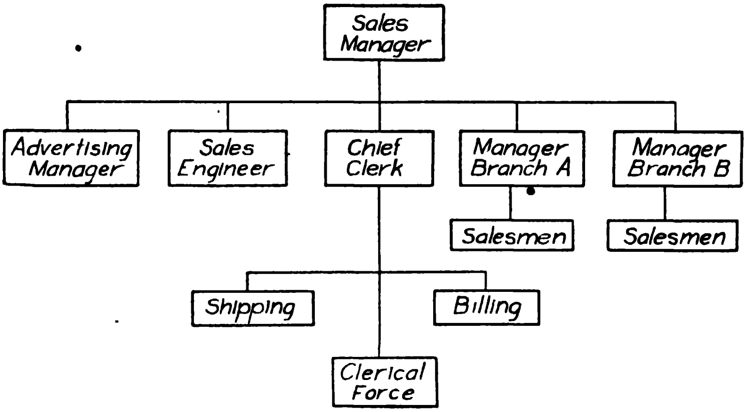

FIG. 23.—The sales unit.

MANAGEMENT METHODS

It has been said that management consists of:

The systematic use of experience.

The economic control of effort.

The promotion of personal effectiveness.

A guiding thought to be observed in the adjustment of the systems of control by means of which any executive may function successfully, is one expressed by H. L. Gantt, namely, "The authority to issue an order involves the responsibility to see that it is executed." Every effective plan of action must meet this test.

Another consistent thinker, C. E. Knoeppel, has enunciated certain "principles of industrial engineering" which are comprehended under the suggestive words—*investigation, coördination, records, planning, standardization.* These five phases of activity, directed toward the control of production operations, constitute

the active steps through which "the systematic use of experience" and "the economic control of effort" may be realized. The third portion of managerial control, "the promotion of personal effectiveness," is embodied by implication in these five phases of action.

The basic considerations which lie behind these several expressions of content and active methods for accomplishment of the ideals of management, are essentially the same. Each statement indicates the necessity of establishing standards of accomplishment, in doing which the experiences of the past and systematic studies of present possibilities are drawn upon. To make effective the lessons of the past and the attainments of the present, there must be developed a system of recording the facts which will be effective and capable of presenting in vivid manner those things which the executive in control must know, and on which he may base a constructive program for further progress. *Standards* and *methods* have become the keynotes of modern industrial activity. With these, as a necessary accompaniment, comes the *graphical presentation* of facts, picturing the degree of attainment that has been achieved in the effort to meet standard performance.

Production Orders.—The machinery of production is set in motion through the issuing of orders by the executive in charge. Previous to their issuance a great deal of preliminary work has been done along lines of design of product, planning of the selling program, and purchasing of material. Sales orders may specify types of product and dates of completion, or the selling plan of standardized articles may call for the manufacture of a stated quantity of goods to go to the warehouse. Such adaptations of production to market have been fixed by company policy, and it is the business of the operations branch to adjust its activities thereto. It is to be assumed that the plant has passed through the preliminary stages of building up its business, so that new demands upon the production divisions are to be worked into the manufacturing program in a manner that will insure the best utilization of space, equipment, materials, and working personnel.

The first steps are taken in the planning or production control department. The new order for goods must be analyzed and the several operations to be performed worked out in detail as to space, equipment, and time requirements, unless it be an item of product which has already been standardized. If the latter

condition holds, then the steps are simplified. When the requirements on the producing plant have been determined, the next step is to fit the work into the routine of the several branches, so that old and new orders and lots may proceed smoothly, with material finding its way to machines and finally to the assembly without congestion or vacant periods. When the study is completed the schedule of work for the new order is prepared.

This schedule in the making has called for detailed information as to time requirements, supply of materials, producing capacities of departments and of individual machine tools, time required in making new tools and jigs by the tool room force, labor conditions, and present demands on working space at bench and assembly. It has brought into action several branches of the planning department. The condition assumed is that obtaining when production is adjusted according to varying market demands.

When work is being laid out for a plant engaged on a predetermined production program, the schedule takes on a different form. For some designated period of time, possibly for an entire year or some fraction thereof, company officials in conference with the sales manager have decided on the exact amount of each article to be manufactured. If this program is to be limited only by plant capacity, then the planning department is called into conference for information as to what may be accomplished in the way of bettered manufacturing conditions. If the program is below plant capacity, then the statement of what is to be done goes to the department, with instructions to plan a scheme for reducing the operating force so as to insure economic production. In either case the schedule of work is laid out so as to insure delivery of goods of the several kinds at the times when they are needed for the trade. Purchases of material are then planned in accord with the program, and work for the several divisions and machines laid out as already indicated.

Production orders are issued to the several operations branches in accordance with the schedule of work. If castings are purchased this means the ordering of the requisite number from the party supplying. Such orders often pass direct from the planning department without going through the purchasing agent's office, just as though the separately owned foundry were a branch of the company plant. Dispatchers prepare their routine order forms, instruction cards for guidance of workers on separate jobs are

prepared, and the control board set in order to receive the various indicators which show the sequence of events in issuing material and recording progress in different departments. The accompanying illustration shows a form of production order, but space does not permit of a full development of details of handling these orders and department records as carried out with dispatching

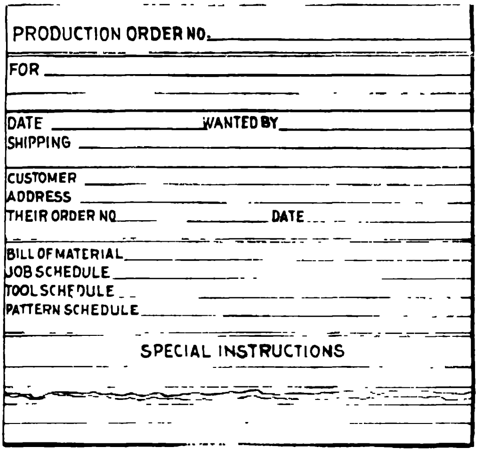
PRODUCTION ORDER NO.
FOR
DATE WANTED BY
SHIPPING
CUSTOMER
ADDRESS
THEIR ORDER NO. DATE
BILL OF MATERIAL
JOB SCHEDULE
TOOL SCHEDULE
PATTERN SCHEDULE
SPECIAL INSTRUCTIONS

FIG. 24.—The production order.

and control boards. Each company has its own specially developed methods for doing this work, and descriptive material in published form is available for those who are interested in following the subject further.[1]

Routing of Work.—Closely related to the preparing of schedules and the production control agencies is routing of work in its progress through the plant. This has its beginning in the original design of the plant, and was treated in such connection in the chapters of Part I dealing with design and layout of equipment. It is to be assumed that equipment has been placed so as to accommodate the easy flow of material as considered in its major phases.

With the progress of work, however, careful adjustment is necessary, especially when product varies. It is not uncommon to find that some machine which may be well placed for economy in movement of material for one article of output, is badly placed with reference to use in the manufacture of parts of some

[1] See KNOEPPEL'S "Graphic Production Control," Chapter XIX, and CHURCH'S "Manufacturing Costs and Accounts," McGraw-Hill Book Co.

other article. In this respect the machine tool layout may be in a condition of change as experience develops the original maladjustments.

Quite aside from studies directed toward better placement of machines, there are routing studies to be made for each production order. Conclusions from such study are involved in the preparation of the dispatching program referred to in the preceding section, and are also used directly in controlling operations of the materials handling and follow-up service. Graphical studies of routing are important adjuncts, not only as means for making more effective the work itself but also to furnish convincing evidence of any troubles or defects, and as guides to the planning of improvements.

Standards. No single rule can be laid down that will apply to all forms of industry in this important matter of standards. Each plant has its own peculiar type of work—many different types often being current in the same establishment. Varying local conditions have much to do with the characteristics and capabilities of workers. The mental attitude of employees demands consideration, and before carrying through a program based on performance records certain preliminary steps may be necessary, leading to quite different conclusions as to methods of making a study of present operating possibilities. The opinions and ideals of administrative officials have much to do with the process which the production engineer may employ in the work. That there must be a standard for the measurement of performance is universally agreed, but the methods employed in arriving at that end are many.

To some, the time study with all its elaboration of detail is the agency through which everything worth while will be accomplished. To others, this will be of minor importance, employed in a more general way for a limited number of operations. Records of the past have a certain significance, the amount depending upon the character of production records of the past, but even when this resource appears in its best light some independent studies should be made to determine how nearly past achievement measures up to present possibilities.

When speaking of standards one must not fall into the error of thinking only of standard time on work applied directly on product. Many plant executives have been swayed in their opinions by preconceived ideas in this respect. They have been

able to see true accomplishment in plant economies only as the time of direct labor has been reduced. Standards for material, for use of tools, equipment, and building space, for plant service in such matters as power and maintenance, and for the indirect service rendered in the offices of the superintendent and general officials, are of real significance. It is quite within the range of probability that the savings effected through standardization of practice in the many and varied indirect service operations about the plant may have a greater effect upon the ultimate cost of production than will the economies produced through increased effectiveness of direct labor. This means that it is not a small or a simple task that lies before the production expert who is charged with the problem of establishing a betterment program.

In addition to standards on the many single process steps and individual tasks, there must be fixed standards on combined results. Costs of completed articles may be standardized to furnish a basis of comparison for the actual results secured in operation. The operating costs of entire departments may be rated on standards set for best conditions. So it is with performance records of machines, of machine groups, and of entire plants. Standards for continuity of production through annual periods are important for comparisons with current producing rates. Sales standards as to quantity and spread throughout the year have a special significance, especially when some of the articles produced are seasonal in market demand and efforts are being made to develop other articles which will supplement the original and serve to steady the manufacturing schedules.

There is no royal road to the setting of standard performance where the human element enters into the case. With stop watch and pad, or from judgment based on past records or experience to guide one in making a good guess, decisions must be made and adopted at least as tentative bases for reference, perhaps to be changed as time goes on. For simple time standards the clock governs, as in the cases of utilization of machines or of whole machine groups when the ideal is continuous operation. For production rate of the plant as a whole, the standard may be fixed by some dominating element of equipment in continuous process industries, like flour milling or cement manufacturing. For industries in which process and labor govern, the absolute standard is a combination result derived when all of the individual elements are operating at standard rates. Whatever the

method and the conditions, some one must assume responsibility and decide what is to be used as the comparative basis, resting in the assurance that comparative calculations only are to be made and that an error in absolute amount may not have serious results.

Graphical Records.—Authority having been exercised in the issuing of orders on production, responsibility follows for seeing to it that results are obtained. This is the supreme test of management. The executive has depended upon his planning force to arrange work schedules, routing plans, and dispatching systems; to design tools and methods; to prepare instructions; and to devise material handling and follow up plans. Under his authority the working instructions have been issued. Now, in the analysis of results, he can only call upon that same directing force to provide him with complete information respecting the conditions under which work has progressed. The presentation of that information must be in such form that he may detect failures to attain to standard performance, and the causes of those failures. It is on such basis that steps may be taken to remedy the conditions which have led to inferior results. Experience has demonstrated the usefulness of graphical records for this purpose.

The basic records to be taken are on labor time, both direct and indirect; stock records, showing amounts issued and amounts spoiled or wasted; machine time; specific causes for lost time of both men and machines; and periodic statements on amount of finished product and progress on orders in process. Any special conditions as to service department operations, unusual repairs on equipment, and condition of materials supply should also be recorded. Portions of these are transmitted in the form of written reports to the executive, but the major part may be compiled in graphical form for more ready reference.

Two forms of graphical record will be presented. One is the so-called Z-chart, the purpose of which is to show the trend of volume of production. It is an index of what is going on in the plant as a whole, and is of interest not only to the head of the manufacturing division but to all heads of departments and general officials. A similar record of sales, or of warehouse stocks, or both, should be compiled by representatives of the department having them in charge. The other is the Gantt chart, which shows performance in relation to time and standards. Careful study should be given to both of these important types of record.

The Z-chart is constructed on a simple plan and is a notably effective means for presentation of the facts of production. The

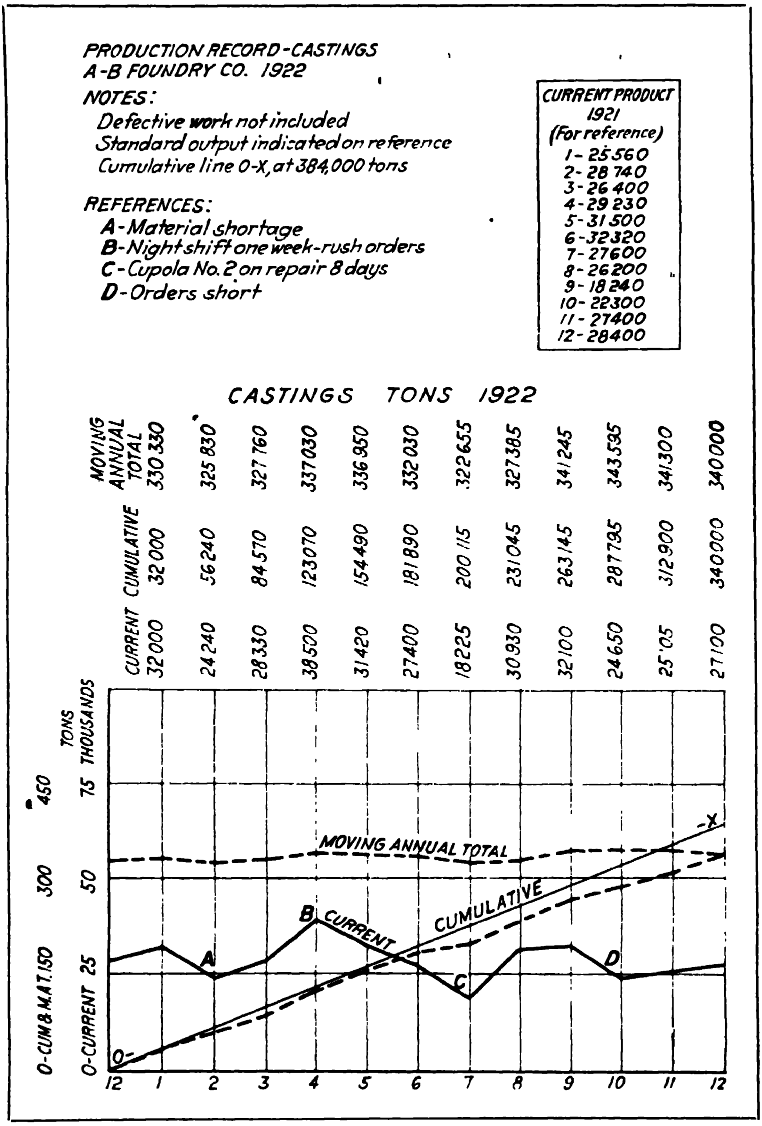

FIG. 25.—The Z-chart.

accompanying diagram is prepared to illustrate its main features. It consists of a plain sheet of paper, a portion of which is laid out in a form of a rectangle divided into 12 spaces to represent

the 12 months of the year. The division line at the right-hand edge of each space is used as the line on which to lay off upward to scale the production quantity pertaining to the preceding month. These monthly spaces may be subdivided to show the record by weeks if it is so desired.

Three sets of quantities are represented. The first is the simple monthly record of production. It is designated as the current record. The scale figures which apply to the current record are those placed close to the left-hand margin of the diagram. The second is the cumulative record, found by adding each month's current production to the total which has preceded, beginning with the first of the current year. It mounts upward, until at the right-hand margin of the diagram it shows the total annual production.

The third is designated as the moving annual total, frequently referred to by those who are constantly using the chart as the M.A.T. or the "mat." The value is found at the end of any monthly period by taking the total production of the preceding 12 months, adding thereto the current month production and deducting the production of the corresponding month of the previous year. In other words, it is the total production of the 12-month period ending with the current month. The cumulative and mat curves are laid off on the scale indicated by the figures given at the left of those which apply to the current record.

Above the diagram there are recorded the actual figures for the three sets of records. To make possible the calculation of the moving annual total, there is also given, on this illustration, a set of values for the 12 months of the year preceding that to which the chart applies. In the lower left-hand corner notations are made relative to conditions which may have influenced the production rate, or attendant facts which the executive should understand when studying the conditions revealed by the chart.

This chart makes possible a study of actual performance in relation to standards which have been set for production during the year. This is indicated by the light line drawn just above the cumulative record reaching up to a point *X* which represents the expected production of the year, 384,000 tons. Wherever the cumulative record falls below this line there is evidence of failure to attain to the standard. The reasons for deficiencies in production rate or notable excesses of normal production, are indicated by the reference figures *A*, *B*, *C*, *D*. This furnishes information as to why production has failed to hold to the standards.

In the actual use to which the chart is put by plant executives, the moving annual tonnage record is the one given most attention. It furnishes a running comparison between the rate of business being carried on for a standard fiscal period ending with the current month, with that carried on during the preceding years. Charts for successive years are compared and the trend in production is readily noted. The mat curve is manifestly one not affected greatly by temporary variations in the production rate, and thus is a steadying influence on one's judgment. If, however, it shows a persistent tendency either upward or downward there is evidence of a situation tending definitely toward progress or deterioration as the case may be. The chart as a whole serves as an indicator to the management that conditions either are favorable or are in need of investigation. It does not reveal the points where action should be taken to remedy a defect, excepting in very broad terms. It is the function of the Gantt chart to give this more specific information.

In the Gantt chart[1] the basic element is time. As shown in the accompanying diagrams the horizontal dimension is taken to represent working periods, usually with the day as the unit and either one week or two weeks represented in the entire width of the sheet. Divisions of time smaller than the day are taken, for greater convenience in estimating, by dividing the day space into four or five parts by the ruling of light vertical lines. An indicating line drawn horizontally through a portion of the space representing one day may thus be estimated with a fair degree of accuracy in terms of the percentage which its length bears to the full width.

The purpose to which the chart is put is to show the extent to which a man or group of men has produced during a given period, or the extent to which machines or whole groups of machines have been employed in actual producing operations. A double system of lines, drawn horizontally across the spaces, is employed in doing this. One is a light narrow line and the other a broad and heavy line. Variations in the width of lines may be employed to distinguish the larger group, or an entire plant, from an individual machine record. The marginal record at the left contains notations which show just what character of data is

[1] For a more complete description of the Gantt chart see the volume under that title, by WALLACE CLARK, published by the Ronald Press.

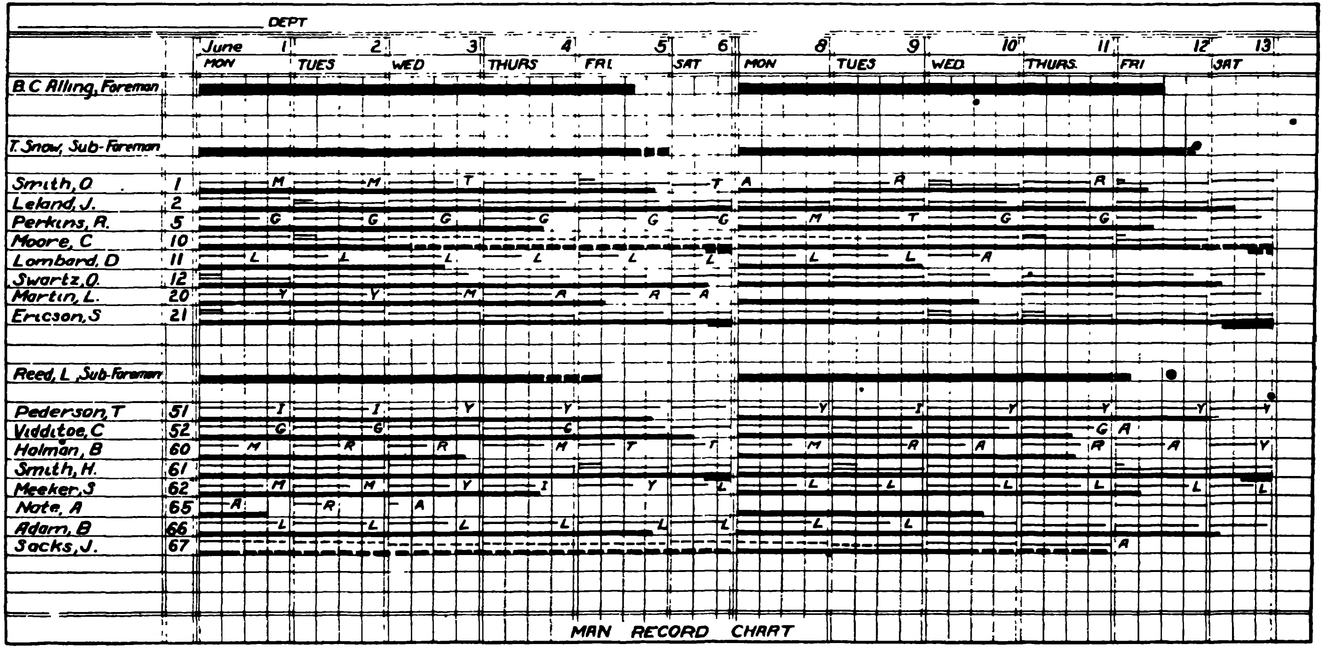

FIG. 26.—Gantt chart.

Definition of Reference Letters

A—Absent	*L*—Slow operator	*T*—Tool troubles
G—Green operator	*M*—Material troubles	*V*—Holiday
I—Lack of instructions	*R*—Repairs needed	*Y*—Smaller lot than estimated.

- - - - - - Time spent on work not estimated shown by broken line

being represented, but this varying width of the heavy line serves as an aid to the eye.

Taking the man record chart, shown on the preceding page, as an illustration, the light line along the upper portion of the space shows that on Monday, July 11, Q. Smith produced three-quarters of the standard amount for the day, the deficiency being caused by some trouble in the movement of material to his machine. On Tuesday his record shows slightly better, but material trouble continued to cause some loss. On Wednesday tool trouble was the cause of still greater shortage in production than on either of the preceding days. On Thursday the record shows that he performed the exact amount of work called for, while on Friday he performed somewhat more than the standard amount, the excess being indicated by the short portion of line drawn parallel to the first. On Saturday tool trouble again prevented his reaching standard performance.

This running record, taken day by day through the week, is now consolidated into the heavy line drawn just beneath the daily record line above referred to. The heavy line is the cumulative record and shows that this man produced during the entire weekly period the amount of work that would have been produced, if production had gone on at standard rate, in a period of 4.85 days. By use of the reference letters, *A*, *G*, *I*, *L*, *M*, *R*, *T*, *V*, and *Y*, the cause of failure to reach standard performance is explained. The persistent recurrence of any one of these letters on the chart means that attention is needed to remedy the condition which is making trouble. A thorough study of the chart in its varying applications to men and equipment, reveals its great value as a record of events as well as an index to the smoothness with which the varied operations of the plant are being performed.

The machine record chart shows the same facts for the various machine tools as does the man record chart for workers. At the top of the chart is a very wide line showing performance of the entire plant. Below are three lines of width next in magnitude, showing the records of the several groups of machines—drill presses, boring machines, and milling machines. The lines next in width give the cumulative records of individual machines, designated by number. The daily record lines are all drawn fine. A set of reference letters is given below the chart, some of them differing from those which apply to the man record. A study of

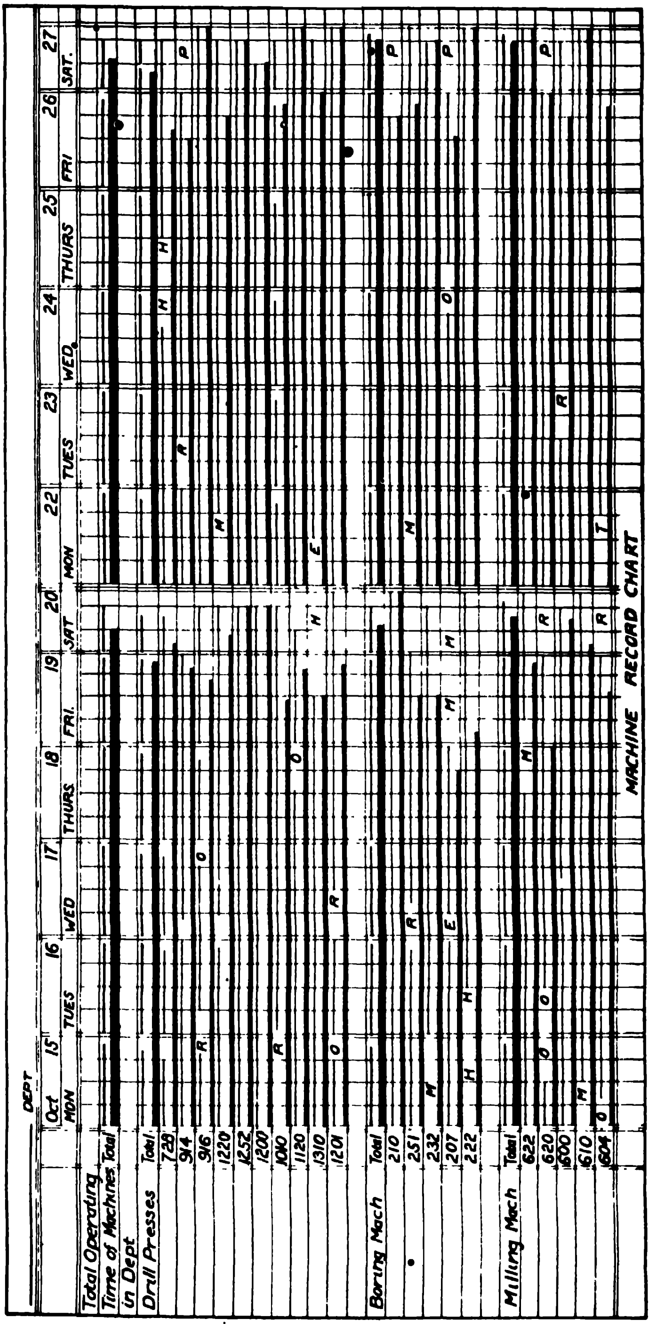

FIG. 27.—Gantt chart

Definition of reference letters

E—Waiting for set-up
H—Lack of help
M—Lack of material
O—Lack of orders
P—Lack of power
R—Repairs
T—Lack of tools
V—Holiday

the machine chart reveals trouble spots where attention is needed, as with the man chart.

The third illustration shows a Progress chart in one of its many forms. It applies to a plant manufacturing on orders, the progress of each job being indicated by the heavy horizontal lines. Each order is scheduled for time of starting and finishing, as is also each of the operations to be performed. The heavy angle, ⌐, opening to the right is placed at the date when materials are to be issued. The similar angle opening to the left is at the date of finishing, presumably when delivery has been promised. The figures above the line indicate the processes, and are placed at the date when work on the process is to start as scheduled. The large V at the top of the chart indicates that the record is of the date corresponding, in this case the morning of December 1. (November 29 is Sunday.)

The record is interpreted as follows. Order No. 3601 is to be finished December 11, to accomplish which the first process in building had to begin on October 16. Materials were issued on October 15. At the date of record the work has progressed exactly according to schedule and the ninth operation is to be started the next day. The next order, No. 3602, which had the same starting date, has been progressing faster than the schedule and is 7 working days ahead, ready for operation No. 8. The third, No. 3603, was to have been completed on November 27, but operation No. 5 was held up on account of tool trouble the preceding morning. The fourth, No. 3610, was finished on schedule, as was also order No. 3613. Number 3611 was held up the day before for repairs on the tenth operation machines, and may need attention. Number 3616 should have been completed on this date, but was held up on the morning of the twenty-seventh by absence of help. If this last job is one on which delivery is important, the absence of the workman is causing serious trouble. Reference to the production order and its schedule will reveal just where the job is and the identity of the workman. A record such as this, ready on the desk of the manager in the morning, *gives him at a glance the information he needs* as to progress of orders and as to where his attention may be needed.

The different forms of record on plant activities which may be presented on Gantt charts is almost without number, depending on the character of the enterprise. The man record lends itself to a study of idleness, of the ability of men to produce on schedule

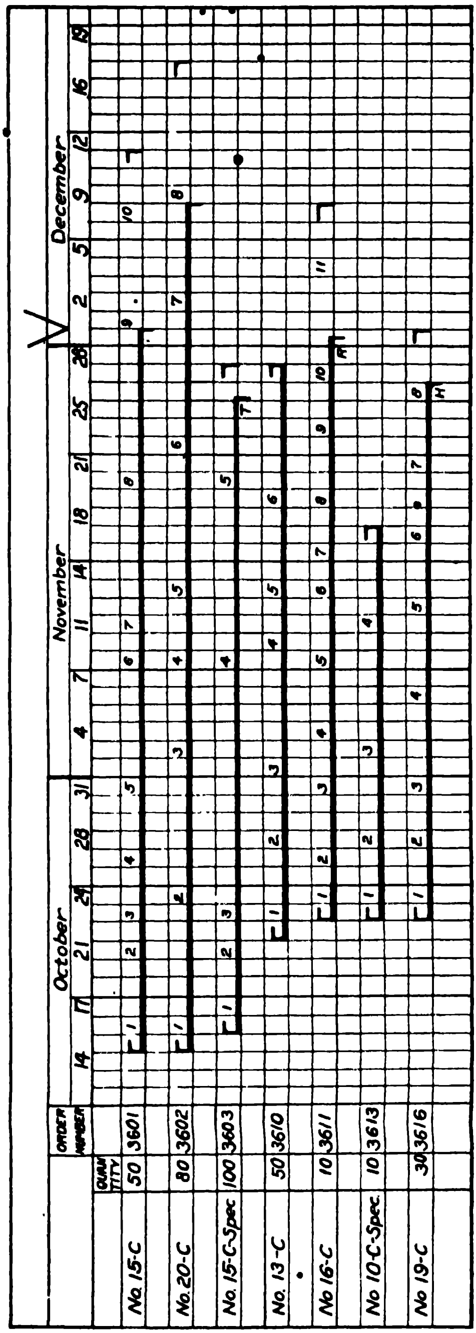

FIG. 28.- Gantt chart for manufacturing on order.

time or to earn bonuses, and of various other personal characteristics. The machine record chart is applied in many ways, notably in studies of the earning capacities of machines in relation to cost and investment charges, and of layout of machines in the plant. The load chart, to show the continuity of demand of the work orders on plant equipment, is a form of machine record chart. The "progress of work" chart is applicable to continuous process manufacturing the same as to manufacturing on orders. It may be used in studying the operations on individual machines or in departments. Work in the various offices may be charted. One adaptation gives an excellent comparative record of orders and shipments, for both purchasing and sales departments. Considered as a whole, the Gantt chart system represents one of the most notable advances which has been made in the field of managerial control.

Measurement of Management.—The continually increasing stress that is being laid on management methods in the entire field of our producing industries is tending toward the setting up of standards which will make possible the calculation of managing efficiency. The responsibility of management for effective production was called forcibly to the attention of the public by the report on "Waste in Industry" issued by the Federated American Engineering Societies. The technical press is replete with discussions of management methods and of accomplishments attained. All of this leads naturally to the question of a possible measurement of the results of management in terms that pertain directly to the acts performed.

Such comparison of performance must be in explicit terms if it is to be of significance. This means that each branch of activity engaged in by the managing staff must be segregated from the others. Each phase of a manager's duties is, or should be, directed toward the accomplishment of some definite result, and each one should be weighed as to accomplishment against a standard. A combination of the partial performances would then give an over-all efficiency, just as the combination of results in the several divisions of a steam power station gives the efficiency of the entire plant. It is manifest that difficulties will be encountered in setting the ideal performance, and that this ideal will be advanced with increasing experience and improved facilities in the form of better designed plants. Variations of this kind can be eliminated, however, by stating the standards in

terms dependent upon physical limitations of equipment, thus making the comparison one that will indicate only the personal achievement. What is sought is measurement of a purely human result by impersonal means.

The recording of accomplishment by the graphical methods which have just been described is a move in the direction desired. Studies of man and machine performance suggest directly the ideal result. Failure to measure up to the ideal is due to the failure of someone to do all that was expected. Where to lay the blame—whether on management or labor, or on conditions outside the control of the producing organization—is the question. It is clear that management's efficiency record should not be made to suffer on account of adverse market conditions, for example. It is premature to attempt the development of a finished plan, but it is time to begin giving thought to the matter.

A few standards may be suggested. For the purchasing department the basis is that of the average market prices on all materials purchased during the month. If the agent has gaged the market correctly and placed orders at opportune times, his record will be high. For the sales department it will vary with the character of product. With a product going to the general trade, the standard is the price at which sales are made; with a standard specialty, it is the amount; with a varied list of manufactured articles, it is the balance of sales through which all branches of the plant are kept in operation.

In the manufacturing department the test comes on the effective use of material, machines, and men. Material should be worked to form without waste. Machines should be employed continuously in relation to the extent to which work orders on hand would require their operation when jobs are performed in standard time. If it is impossible to balance equipment perfectly, some machines work only part time while others work all of the time. A standard for men would be performance records clear from the interruptions from causes listed on the Gantt charts, which could be eliminated by perfect coördination.

All these are suggestions, merely, in an undeveloped field[1] which is awaiting exploration and systematic study.

[1] The pioneer in this field is Professor Jos. W. Roe, to whom the author is indebted for suggestions. See article by Professor Roe in *Mechanical Engineering*, November, 1923.

PERSONNEL CONTROL

The selection and training of workers constitute one of the important divisions in management. Comment has been made on the personnel or employment department as a distinctive branch of the organization, but the actual methods of handling this department remain to be considered. Adding new members to the working force by the hit-or-miss method of receiving those who apply in response to notices or advertisements regarding positions vacant does not yield results. The head of an employment division, under ordinary conditions, will maintain a list of available workers and determine in advance the chief characteristics of the applicants. While this may not always be possible, the active employment agent will see to it that he knows something of the nature and life history of workers before they are taken on the force.

To make this possible there must be coöperation between heads of the various operating departments and the employment office. Reports should be made by the different departments showing the present condition of the working force, and impending vacancies either from men quitting or being promoted, or through projected additions to the working force. This should be accompanied by a statement of the nature of the work to be performed and any special qualifications which are necessary. Through such reports the director of employment is able to forecast the needs of the company for a period which will vary according to conditions, but which should be not less than two weeks. From the list of applicants, or, if this list is short, through inquiries which will bring to light possible workers in the vicinity or others who may be brought when occasion demands, he may then select those who, by nature and by training, meet the requirements. This practice makes it possible to bring a higher type of employee into the plant and results in a diminished cost of training.

When the time comes for the employee to begin his work he has already been designated for assignment in accordance with his abilities. He is passed on to the foreman of the gang or division where his specific training for the job is begun. Should he prove to be unfitted for that work he is not at once cast adrift but is returned to the employment department which then proceeds to find the position for which he is adapted, if conditions make it possible. There is always the possibility of a shift among members of the force by which someone may be promoted to the posi-

tion originally in view and thus open the way for the prospective employee. It is by such manipulations, based on a careful study of the needs of the different departments and of the character of the available men, already in the plant or applicants, that the employment superintendent really performs his true function.

In the employment office two sets of records are kept. One has been referred to as the waiting list. This record embodies the name and general description of the man, together with a record of his past employment and experience, information as to his nationality, his family, and status as a citizen of the country, the conditions of his home and its surroundings, the scale of living which he has been able to maintain through his earning capacity, and such other information as may be determinable.

The other is a record of employees. This record should include the history of every worker, from the time of his entering the plant. It covers such items as the kinds of work which he has done, his success in meeting the requirements of the job, and full information as to his advances in rank and in pay. In addition to these facts pertaining to his work for the company, there should be included information as to his development and training, facts as to his home life, the opportunities which he has found for recreation or other forms of self-expression in his private and social life. It is manifest that such a record is one to be consulted when questions of promotion are at stake. They supplement the official performance records of the man on his job which are kept in the files of the planning department or of the department in which he works.

The employment superintendent, in coöperation with the heads of the operating departments, should include in his dealings with employees a study of absenteeism. The habit of irregularity is one of the most troublesome features in the conduct of an industry, but it has been demonstrated many times that consistent study of the underlying causes and motives which influence the workers will produce gratifying results. Absenteeism will show up prominently in any adequate system of graphical records, and thus it is bound to come to the attention of the executive in charge of operations. The employment superintendent should be in conference, and may take a prominent part in carrying out the plans which may be formulated for combating this evil. Methods of meeting the situation are not under discussion at this point, further than to observe that the employ-

ment department should take cognizance of the situation, and in the record which is kept, of the personal characteristics of employees, give proper place to this characteristic trait.[1]

The activities up to this point are those which pertain to the proper administration of a department designated for the employment and assignment of workers. The records described are those which show the facts which are determinable by observation and inquiry, but which do not necessitate activities designed particularly for the welfare and education of the workers as a group. If these additional activities are to be entered into by the management it means the formation of a welfare branch. When this is done a more appropriate designation is that of a *personnel department* with two branches, employment and welfare. This more extensive line of activities in lines of personnel has not been taken as representative, so no detailed discussion will be given of the various activities which might occupy the attention of the welfare division, further than to note that in certain large industries of the country the work has been carried through with marked success. An approach to it may be made in smaller enterprise through a simple organization, by instituting a moderate program for education of workers in general lines in addition to the special training called for in the work itself. Under proper guidance such activities will yield good results. The possibilities of carrying on this work without the special welfare division depends upon the energy and capacities of the employment head, as well as upon the size of the plant.

Measured in terms of economies secured, the work of the employment department is effective in the reduction of labor turnover. A successful employment superintendent will reduce the cost of breaking in new workers through wise selection and appropriate assignment to jobs, and by these same acts, coupled with continued attention to the workers on the job, reduce the number of those who quit. Since the cost of turnover is measured by the product of the cost of training the workers and the number of workers taken into the plant, the saving is a double one. That the practice of maintaining a department of this kind justifies itself wherever conditions are at all favorable is attested to by

[1] A valuable contribution, and one which every one should read, is an article entitled "The Foreman and the Personnel Department," by Calvin W. Rice, Secretary of the American Society of Mechanical Engineers, published in the September 1920 number of the *Sibley Journal of Engineering.*

the statements of department executives, two of whom have already been quoted in this chapter.

While this saving in the cost of labor turnover is the one directly credited to the employment department, there are bound to be other financial advantages coming as a secondary effect from the work of the successful superintendent. As a result of consistent effort along the lines indicated the worker in the plant will be more productive, for the double reason that he is better prepared for his job, and is working in an atmosphere that is conducive to higher standards. Evidence on this point is not always obtainable in direct terms, but the fact that it is true can be proven by the statements of many administrators who have given the plan adequate trial.

INDUSTRIAL RELATIONS

The supreme test of management is in the maintenance of satisfactory relations with employees. A cordial and responsive attitude is essential to good operating conditions. Under such conditions there is no need for formalized machinery for the adjustment of controversies.

It is not to be expected, however, that such relations can always be maintained. Certain tendencies, which have their origin in human traits unnecessary to describe, lead to unrest and dissatisfaction, frequently originating in misunderstandings or through influences coming from sources outside the organization itself. The management forces must recognize this fact and should give intelligent study to methods of dealing with disputes which may arise in spite of sincere efforts to prevent their occurrence.

In recognition of the need for industrial harmony, an Industrial Conference was convened in Washington by President Wilson, December 1, 1919, for the purpose of inquiring into causes of unrest and suggesting means for the adjustment of difficulties. The Conference reconvened in January, 1920, and prepared a report which contains many suggestive statements. While it represents no compulsory provisions, nevertheless its findings are worthy of careful consideration. A portion of the report is quoted in the following pages, embodying as it does a clear statement on an all important subject by a distinctive group of men, all of whom have had wide experience in business affairs. Unsupported though

it is by governmental authority, it has had undoubted influence in the forming of opinions and policies on the part of many administrative officials, and is a document eminently worth while for consultation. The part quoted deals mainly with causes and prevention of disputes, but includes the statement of a plan of settlement. For a discussion of the settlement plan the report itself must be consulted. While the country may not be ready for compulsory arbitration, and industrial conditions may not favor the general adoption of plans for employee representation, still it is important that these questions receive earnest consideration.[1]

Extract from the Second Report of the National Industrial Conference

The causes of industrial unrest are many. Among others they include the rise in the cost of living, unrestrained speculation, spectacular instances of excessive profits, excessive accumulation and misuse of wealth, inequality in readjustments of wage scales, release of ideas and emotions by the war, social revolutionary theories imported from Europe, the belief that free speech is restricted, the intermittency of employment, fear of unemployment, excessive hours of work in certain industries, lack of adequate housing, unnecessarily high infant mortality in industrial centers, loss of personal contact in large industrial units and the culmination of a growing belief on the part of both employers and employees that a readjustment is necessary to a wholesome continuity of their united effort.

For the most part causes of unrest are not the result of the war; they have been accentuated by it. Much investigation and public discussion have been devoted to these matters. The relative importance and emphasis laid on the different causes varies with each investigator. The Conference, in Part IV, has made suggestions for dealing with some of the conditions enumerated, and it hopes that progress toward remedying them may be accelerated by the further development of employee representation and by the use of the suggested machinery for adjustment.

There is, however, a feature of the present industrial unrest which differentiates it from that commonly existing before the war. It cannot be denied that unrest today is characterized more than ever before by purposes and desires which go beyond the mere demand for higher wages and shorter hours. Aspirations inherent in this form of restless-

[1] For further discussion of personnel matters the reader is referred to the treatise "Personnel Administration," by Tead and Metcalf, McGraw-Hill Book Co.

ness are to a greater extent psychological and intangible. They are not for that reason any less significant. They reveal a desire on the part of workers to exert a larger and more organic influence upon the processes of industrial life. This impulse is not to be discouraged but made helpful and coöperative. With comprehending and sympathetic appreciation, it can be converted into a force working for a better spirit and understanding between capital and labor, and for more effective coöperation.

The wisest suggestions for the prevention and relief of industrial unrest are to be found by interpreting the best thought and experience of those employers and employees who, within the area of their own activities, have most successfully dealt with the problem. The Conference in making its final report has considered the interpreting of actual achievements its most useful function. It believes that practical experience is more useful than the views of extremists on either side. Such experience shows that no group of men can successfully undertake to deal with the interests of other groups without their coöperative participation in the methods of equitable adjustment.

The guiding thought of the Conference has been that the right relationship between employer and employee can be best promoted by the deliberate organization of that relationship. That organization should begin within the plant itself. Its object should be to organize unity of interest and thus to diminish the area of conflict, and supply by organized coöperation between employers and employees the advantages of that human relationship that existed between them when industries were smaller. Such organization should provide for the joint action of managers and employees in dealing with their common interests. It should emphasize the responsibility of managers to know men at least as intimately as they know materials, and the right and duty of employees to have a knowledge of the industry, its processes and policies. Employees need to understand their relation to the joint endeavor so that they may once more have a creative interest in their work.

Industrial problems vary not only with each industry but in each establishment. Therefore, the strategic place to begin battle with misunderstanding is within the industrial plant itself. Primarily the settlement must come from the bottom, not from the top.

The Conference finds that joint organization of management and employees where undertaken with sincerity and good-will has a record of success. The general principles governing such organization are stated at length under the title, "Employee Representation." It is not a field for legislation, because the form which employee representation should take may vary in every plant. The Conference, therefore, does not direct this recommendation to legislators but to managers and employees.

If the joint organization of management and employees in the plant or industry fails to reach a collective agreement, or if, without such joint organization, disputes arise which are not settled by existing agencies, then the Conference proposes a system of settlement close at hand and under government encouragement, and a minimum of regulation. The entrance of the Government into these problems should be to stimulate further coöperation.

The system of settlement consists of a plan, nation wide in scope, with a National Industrial Board, local Regional Conferences and Boards of Inquiry, as follows:

1. The parties to the dispute may voluntarily submit their differences for settlement to a board, known as a Regional Adjustment Conference. This board consists of four representatives selected by the parties, and four others in their industry chosen by them and familiar with their problems. The board is presided over by a trained government official, the regional chairman, who acts as a conciliator. If a unanimous agreement is reached, it results in a collective bargain having the same effect as if reached by joint organization in the shop.

2. If the Regional Conference fails to agree unanimously, the matter, with certain restrictions, goes, under the agreement of submission, to the National Industrial Board, unless the parties prefer the decision of an umpire selected by them.

3. The voluntary submission to a Regional Adjustment Conference carries with it an agreement by both parties that there shall be no interference with production pending the processes of adjustment.

4. If the parties, or either of them, refuse voluntarily to submit the dispute to the processes of the plan of adjustment, a Regional Board of Inquiry is formed by the regional chairman, of two employers, and two employees from the industry, and not parties to the dispute. This Board has the right, under proper safeguards, to subpoena witnesses and records, and the duty to publish its findings as a guide to public opinion. Either of the parties at conflict may join the Board of Inquiry on giving an undertaking that, so far as its side is concerned, it will agree to submit its contention to a Regional Adjustment Conference, and, if both join, a Regional Adjustment Conference is automatically created.

5. The National Industrial Board in Washington has general oversight of the plan.

6. The plan is applicable also to public utilities, but in such cases, the government agency, having power to regulate the service, has two representatives in the Adjustment Conference. Provision is made for prompt report of its findings to the rate regulating body.

The Conference makes no recommendation of a plan to cover steam railroads and other carriers, for which legislation has recently been enacted by Congress.

7. The plan provides machinery for prompt and fair adjustment of wages and working conditions of government employees. It is especially necessary for this class of employees, who should not be permitted to strike.

8. The plan involves no penalties other than those imposed by public opinion. It does not impose compulsory arbitration. It does not deny the right to strike. It does not submit to arbitration the policy of the "closed" or "open" shop.

The plan is national in scope and operation, yet it is decentralized. It is different from anything in operation elsewhere. It is based upon American experience and is designed to meet American conditions. It employs no legal authority except the right of inquiry. Its basic idea is stimulation to settlement of differences by the parties in conflict, and the enlistment of public opinion toward enforcing that method of settlement.

Prevention of Disputes

Joint Organization through Employee Representation

Prevention of disputes is worth more than cure. The Conference feels that a new basis of industrial peace may be found in the further development of the democratic organization of the relations of employers and employees, now widely in progress through the country.

Modern industry, as conducted in large plants, has caused a loss of personal contact between employers and employees. It has also caused, through high specialization and repetitive mechanical processes, a loss of creative interest. But it makes possible a greater production of the material things which contribute to the common resources of the people. Upon these resources an advancing civilization, with a higher common standard of living, must depend.

Direct personal contact in the old manner cannot be restored. It is necessary, therefore, to find the best possible substitute through democratic representation. Employees need an established channel of expression and an opportunity for responsible consultation on matters which affect them in their relations with their employers and their work. There must be diffused among them a better knowledge of the industry as a whole and of their own relation to its success. Employee representation will not only enable them better to advance their own interests, but will make them more definitely conscious of their own contribution, and their own responsibilities.

Employee representation has been discussed under different names and forms, such as shop committees, shop councils, works councils, representative government in industry, and others. But representation is a definite principle rather than a form. The Conference, therefore, prefers the generic term "employee representation." In using this

term the Conference has in mind the successful application of the principle to various activities outside, as well as within, the purely industrial field.

From both employers and employees the Conference has received thoughtful and helpful suggestions as to the possibilities, under proper conditions, of employee representation. These suggestions clearly proceed from a genuine desire that this movement may spread in accordance with sound principles and be kept from perversions which would threaten its lasting usefulness by making it an agency of attack rather than a means to peace.

Employee representation organizes the relations of employer and employee so that they regularly come together to deal with their common interests. It is operating successfully under union agreements in organized shops. It is operating in non-union shops, and it is operating in shops where union and non-union men work side by side. In plants working under union agreement, it adds to collective bargaining an agency of coöperation within the plant. It is itself an agency of collective bargaining and coöperation where union agreements do not obtain.

It is idle wholly to deny the existence of conflicting interests between employers and employees. But there are wide areas of activity in which their interests coincide. It is the part of statesmanship to organize identity of interest where it exists in order to reduce the area of conflict. The representative principle is needed to make effective the employee's interest in production, as well as in wages and working conditions. It is likewise needed to make more effective the employer's interest in the human element of industry.

The idea of employee representation has aroused opposition from two sources. On the one hand, in plants too large for direct personal contact, employers who still adhere to the theory that labor is a commodity, hold off from any form of coöperation with employees. This view is steadily disappearing and will, it is hoped, wholly disappear. On the other hand, a number of trade union leaders regard shop representation as a subtle weapon directed against the union. This thought is apparently based on the fear that it may be used by some employers to undermine the unions. Conceived in that spirit no plan can be a lasting agency of industrial peace.

But occasional misuse of employee representation and the consequent hesitancy of organized labor to endorse it officially are based on a misconception of the possible and desirable relations between the union and the shop committee. This relation is a complementary, and not a mutually exclusive, one. In many plants the trade union and the shop committee are both functioning harmoniously. In some establishments the men are unionized, and the shop committees are composed of union men. In others, some men belong to the trade union while all belong to the shop organization.

The union has had its greatest success in dealing with basic working conditions, and with the general level of wages in organized and partially organized industries and crafts. It has also indirectly exerted an influence on standards in unorganized trades. There is no reason to suppose that in the future this influence will not continue.

Local problems, however, fall naturally within the province of shop committees. No organization covering the whole trade and unfamiliar with special local conditions and the questions that come up from day to day, is by itself in a position to deal with these questions adequately, or to enlist the coöperation of employer and employee in methods to improve production and to reduce strain. Except for trades in which the union itself has operated under a system of employee representation, as it does in shipbuilding and in the manufacture of clothing and in other trades, these internal factors are likely either to be neglected or to be dealt with in a way which does not make for satisfactory coöperation.

The existence of employee representation in plants operating under union agreement does not necessarily reduce the scope of the union representative's work. But matters are more likely to come to him as questions of the application of an agreement rather than as mere grievances. In other words he has greater opportunity for service in negotiation of an essentially conciliatory nature. The fortunate results of such development have been evident in industries in which employee representation and trade unions have for some time been functioning harmoniously.

Employee representation must not be considered solely as a device for settling grievances. It can find success only if it also embodies coöperation in the problem of production. Whatever subjects the representatives come to feel as having a relation to their work, and their effectiveness as members of the plant, may come within the field of committee consideration. It is a thing to be undertaken, if at all, in a thoroughgoing way. Representatives must be selected by the employees with absolute freedom. In order to prevent suspicion on any side, selection should be by secret ballot. There must be equal freedom of expression thereafter. All employees must feel absolutely convinced that the management will not discriminate against them in any way because of any activities in connection with shop committees. Meetings should be held frequently and regularly, not merely when specific disputes are threatened. Both sides must be prepared to study the problems presented and must give them patient, serious and open-minded consideration. There should be made available those facilities and facts essential to the formation of soundly based conclusions.

Employee representation offers no royal road to industrial peace. No employer should suppose that merely by installing some system of shop representation he can be assured, without continued effort, of harmony and increased production Doubtless there will be failures

where the plan is adopted as a fad or a panacea. It is only a means whereby sincerity of purpose, frank dealing and the establishment of common interests, may bring mutual advantage.

The development and maintenance of right relations between employer and employee require more than mere organization. Intelligent and wise administration is needed of all those problems of production that directly touch the employee. Conditions affecting human beings in industry were, during the last generation, largely in charge of men whose special training had been devoted to the mechanical side of production. Much study was given to the machinery and processes upon which men worked. But the factors that contribute to the broader human development and satisfaction of the employee and that lead to increased productivity were too nearly neglected. The elimination of human friction is, even from the point of view of increased production, at least no less important than the elimination of waste in materials, or in mechanical power.

Establishments in which the ultimate management is of necessity widely removed from the employees, require provision for specialized study of industrial relations. But the right concept of human relations in industry, which should be the primary impulse of management, is of full value only when it permeates the entire administrative force. Farsighted executives testify to the advantage gained from careful and painstaking efforts to encourage and educate their foremen in the proper attitude toward employees.

A large proportion of men trained in our engineering and technical schools now pass into executive positions. It is, therefore, desirable that these schools should provide courses of instruction in which the psychological and industrial background for human relations work shall be developed. But no amount of education outside the plant will remove the need for the systematic training of the force within.

Some industries have extended the principles of employee representation beyond the individual plant. The voluntary joint councils which have thus been set up in the clothing industry, in the printing trade, and elsewhere are fruitful experiments in industrial organization.

The Conference has had the benefit of testimony from both employers and employees who have had experience of the results of employee representation. An enthusiasm has been shown which comes from a sincere feeling of substantial progress in the development of human relations.

CHAPTER XI

COSTS

Cost considerations are at the center of administration. Cost control is a matter of executive action and its treatment is made the subject of a separate chapter only because of its importance. In the preceding chapter several phases of its handling have been referred to, especially as to its position in the managing organization. On the basis which has been advocated, whereby the production control department attends to the gathering of primary records which are then made available both for the preparation of reports relating to operations and for the more extended work of the cost accountant, close and active coördination is required between the operations planning room and the accounting rooms. This should be considered in the layout of the service rooms in the plant.

In a book devoted to the broad field of Management Engineering there is insufficient space for the development of details of accounting methods. That task is within the province of the cost specialist and many excellent books[1] and articles are available to the reader who desires to follow the subject more closely. The only purpose of this discussion is to bring out those characteristics of costs and cost accounting with which those concerned with the active control of operations should be familiar.

[1] "Production Engineering and Cost Keeping," BASSET & HEYWOOD, McGraw-Hill Book Co.

"Cost Keeping and Scientific Management," H. A. EVANS, McGraw-Hill Book Co.

"Works Management," W. D. ENNIS, McGraw-Hill Book Co.

"Cost Reports for Executives," B. A. FRANKLIN, The Engineering Magazine Co.

"Graphic Production Control," C. E. KNOEPPEL, The Engineering Magazine Co.

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"Managerial Control through Costs," J. P. JORDAN, *Management Engineering*, February–June, 1923.

"What Cost Knowledge Is of Most Worth," G. C. HARRISON, *Management Engineering*, February, 1922.

A knowledge of costs is essential to the successful management of an enterprise. The end and aim of management is to reduce the cost of production. All that has gone before in the way of studies in the effective control of labor, material, and plant service has its point of application in the effect produced on operating cost. To make such efforts effective, those having to do with the problems of management must have an understanding of the elements of cost and of the relative significance of the many items which involve expenditure. In the end every dollar paid out on a transaction, whether it be to parties outside or inside the organization, must be charged against the plant product. To make the enterprise a profitable one, often to make possible its existence, such expenditures must be kept on an appropriate level. Niggardly economies are not representative of efficiency, but it is essential that work be adjusted to a definite plan and all duplication and wasted effort eliminated. To accomplish this calls for regulated control all along the line.

The peculiar opportunities for saving in the operations department have led to the development of the planning and control methods which are now found in representative plants. In other departments the control of activities calls for corresponding measures. It devolves, in great part, upon the cost accountant to act as a planning expert and to devise a system of regulatory checks and reports that will lead to the kind of control required. This means that cost accounting is no longer a mere bookkeeping function. It calls for active study of methods in vogue everywhere in the plant. The expense of maintaining all of the branches outside of the operations department must be treated as a general overhead, and when the product includes more than a single article a system for distributing expenditures must be devised and administered so that the proper amounts shall be borne by each portion of output. This calls for detailed knowledge of conditions and of the character of the many kinds of service. The head of the costs service has become an official with heavy responsibilities and intimate contacts with all parts of the enterprise. His concern is with the future rather than with the past.

Cost Elements.—The terms employed in calculating costs should be understood by all. It is apparent that different methods are employed in handling cost items, which means that correspondingly different methods must be used in exercising

managerial control. The following division is one commonly adopted.

1. *Direct Cost.*—Another term frequently applied is *prime* cost. It is made up of those charges which can be applied to each article produced, such as *direct material* and *direct labor.* By keeping records of machines employed on each job or lot of goods manufactured, it is possible to make direct charges covering several items of expense connected with the operating and

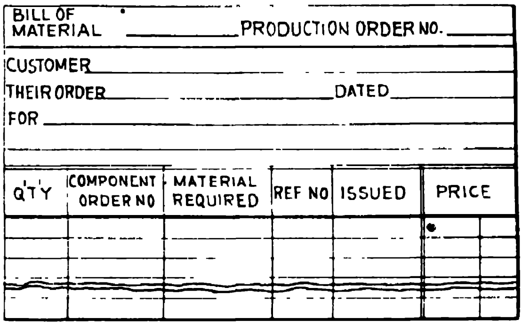


FIG. 29 Material-used record.

maintenance of equipment. The extent to which this is carried depends upon circumstances. In general, it may be said that the direct charging of cost items should be carried as far as it may without involving inordinate labor in accounting, to avoid errors which are bound to occur when general items have to be allocated by approximate rules of distribution.

2. *Factory Expense or Burden.*—After the direct charges have been made there remain many items of expense which cannot be assigned directly to different products. They include salaries of the superintending staff and all members of the factory office force; indirect labor of various kinds employed in moving material, janitor service, etc.; power, heat, and light; repairs and maintenance on equipment and buildings; insurance and taxes on that portion of plant, equipment, and material which relates to the manufacturing division; and special service in tool making and pattern making when those articles are carried over for use on duplicated orders. The last item may be divided and charged directly.

3. *General Expense.*—Sometimes this is distinguished as general office expense, when sales expense is considered separately. When accounting has been developed to a fine degree

the expense of maintaining other departments may be separated from the total. For example, the purchasing expense has a different relation to material than that borne by other office departments, and it may be distributed by a rule of its own. So with the employment department in its relation to labor time. The whole of general expense is usually distributed over product on a different plan than that employed in distributing factory expense. Conditions are so variable in different industries that it must be left to the accounting force to determine the extent of detail to which it may go in making separation of items for distribution.

4. *Profit and Loss.*—This, when added to the total of all that precedes, gives selling price. Of course the actual price may be determined by competitive market conditions so that profit and loss is a derived quantity, but theoretically it is considered as a determinable element. The rational basis of distribution is as a straight percentage on the total cost made up from the actual cost elements. It frequently happens, however, that some articles are sold at a profit and thereby make up losses on others. This serves to demonstrate the true value of correct cost accounting. The management needs to know which articles are the profitable ones to manufacture, as well as which ones need to be investigated for the purpose of reducing actual cost.

Derived terms are *Factory Cost*, found by adding *Direct Cost* and *Factory Expense*, and *Total Cost* which is found by adding to the factory cost the items included in *General Expense*.

Distribution of Expense.—The proper distribution of the factory and general expense constitutes the most complex task of cost accounting. It is evident that it must be done by some plan of proportional calculation, but this requires the selection of the basic quantity that is to serve to fix the ratio. At best it is an approximation and the chance for error becomes less the greater the amount of the direct charges made against any article in proportion to the amount of the indirect.

The basis employed for this distribution process must be one of the directly recorded items of cost, or some combination of them. The one most commonly used in the past is direct *labor time*. When thus employed the total time devoted by labor to the direct production is recorded, together with the total of the expense which remains to be distributed. The ratio of the labor

time charged against any one article of product to the total recorded labor time becomes the ratio of that portion of the expense which is to be charged against the article in question. It is evident that this is a true distribution only in cases when the expense is truly indicated by the time of workers. As a matter of fact this condition never exists. Some items of expense which enter into the sum total to be distributed bear no relation whatsoever to labor time. To use this method of distribution is

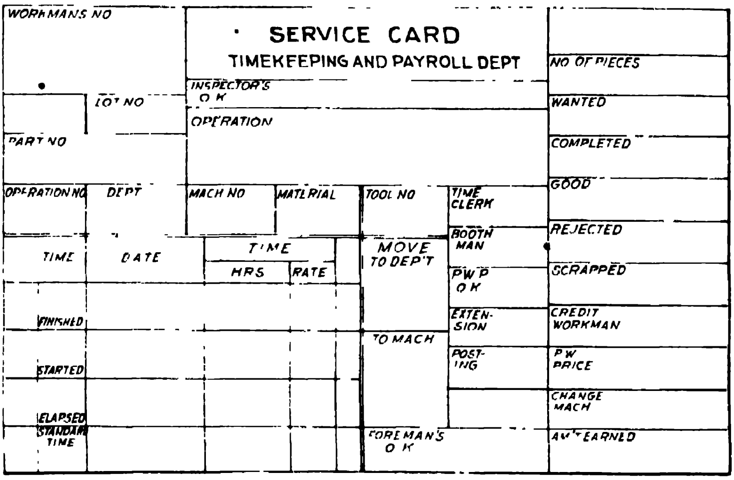


FIG. 30.—Time card.

bound, therefore, to occasion error, the only excuse for its toleration being that every other simple method that has been devised is subject to errors of the same general character.

Another basis which has been employed at times is *labor cost*. It may be argued that certain portions of the total expense to be distributed bear closer relation to the cost of labor than to the labor time. The employment of this method means that articles which have been produced by the higher priced skilled labor, and so have the larger items of labor cost, will be compelled to absorb a larger portion of the overhead than would be the case if the distribution were made in accordance with the direct labor time. Whether this is a more just distribution depends on circumstances. The skilled labor may be associated with high-priced tools and equipment, the maintenance and investment charges on which make up a considerable fraction of the total expense, and so far as this represents the situation the labor cost is a better basis than labor time. On the other hand, it is probable

that the cost of supervision bears more heavily upon the jobs performed by unskilled labor than upon those performed by skilled, and in the same degree will it be true that the labor time method gives the truer figure.

An analysis of these elements of cost in relation to the directly recorded elements leads at once to the idea that the extent of utilization of machines may be employed as the basis for distribution. This is true particularly for those processes in which practically all steps are carried out on machines. Continuous process plants, where the skill of supervisors is devoted largely to the adjustment of equipment and where labor is dominated by the machine, afford instances where machine time is satisfactory as a basis of distribution. In carrying out the work, all that is necessary is to record the total number of hours that each machine is utilized in the turning out of each individual article, from which the total number of machine hours employed directly in the plant for any given period of time follows. The ratio of hours applied to any article to the total for the plant is the index of the portion of the total expense that is to be charged against the article in question.

While this gives satisfactory results for industries of the character referred to, machine time is far from being satisfactory for the majority of plants in which the process involves labor in its more varied forms. For such plants machine time may be made to serve as a basis for the distribution of certain portions of the general expense, but to attempt to distribute the entire amount gives rise to serious errors.

As a matter of fact, no one of the three simple bases, labor time, labor cost, or machine time, is quite suitable for any plant engaged in general manufacturing wherein both machines and independent labor exert important influences on the cost of production. Because no one of these does serve adequately, the distribution of expense is the difficult task that it is. No perfect system has been devised, but various plans have been evolved which eliminate some of the errors which accompany the simple methods. These more complicated methods require more work for administering, but accuracy is not to be expected without effort. It is a question simply of whether a method can be devised, such that the benefits arising from the greater accuracy will warrant the greater expenditure in operating it. Therein lies the problem of the cost accountant, who must determine by

study of the varying characters of the expense items the bases on which they may best be related to the items of product, and who must decide how far it is worth while to go in making the distribution by methods truly accurate.

Two plans only will be mentioned, these being selected to indicate the characteristics of methods which have been evolved for handling this difficult matter. Under the first the several items which make up the factory overhead are divided into three or more groups. Those items which are of such character that the expense varies with labor time are distributed on that basis. This will include wasted time, heat, light, supervision, employers' liability insurance, insurance on buildings, and indirect labor.

Other items which have a closer relation to machine time make up the second group, to be charged against the product in accordance with machine time. This may include power, repairs and replacements, depreciation of equipment, insurance on equipment, and a portion of taxes. There may be included in this group some portion of taxes, and such professional service and labor as may be applied to the supervision and maintenance of equipment. When these two groups of expense items have been charged against the product and added to the initial direct cost, there results what may be termed "corrected direct cost." This corrected cost may then be used as a basis for distribution of the other items of overhead expense which remain, including administration, selling, designing and development, and various general office accounts. Where the work has been well systematized, such a method of distribution may be administered without great expense, and with results which accord more closely to true costs than can be secured by the employment of any one of the simple bases.[1]

A second method termed the "production center basis" has been devised by A. H. Church. It has been used with success where sufficient attention has been given to making the initial studies. The basic idea is that each individual unit of work is performed in a space definitely allotted to it. Presumably one worker occupies this space. The space is provided with the necessary tools, whether it be an operating machine or bench space. One may imagine each of these production centers to be

[1] For further details of this system see "Works Management" by Ennis, McGraw-Hill Book Company.

assessed in accordance with the value of all equipment within it, and with full charges for light, heat, power, and all forms of miscellaneous service. The sum total of charges made against each center makes up an item which may be considered as rent, reduced to the hour as a unit of time. For each job there will then be recorded the time which was spent at the various production centers so that there can be charged against the job the proper amounts in accordance with the scale which has been prepared.

However completely this plan may be developed, there are bound to be certain items of expense which cannot properly be charged against any of these unit spaces. These left-over expenses must then be charged against product by some one of the established methods, labor time being a common basis.[1]

COST CONTROL

Cost keeping is to be considered as an aid to managerial control. This means two things. Information derived from cost data must be immediately available for use in connection with the administering of producing departments and the checking of all expenditures, direct and indirect; and the cost accounts themselves must be laid out in such form that the indirect expenses may be distributed in accordance with the methods which give most accurate results, for use in the determining of policies dependent upon the costs of the various items of product. To accomplish these objects the book accounts to be carried must be considered carefully.

The gathering of direct data on labor and materials has been treated already, and illustrative forms of time cards and stock records shown. The information carried on these cards is assembled and finally entered as charges against the several accounts in accordance with the following general plan, it being understood that each concern has its own special conditions to meet and that no one outline of method can do more than suggest the purposes to be accomplished.

In the general case an account is carried for these direct charges for each item of product for which the cost is desired. For a plant turning out one continuous product, such as cement or refined sugar, the department cost may be the objective. Time

[1] For details see "Distribution of Expense Burden," A. H. Church.

and material card data will be assembled on sheets prepared for convenience of summation, and the totals entered on job or department cost cards. These cost cards, are, in effect, separate ledger accounts, on which, however, only the debit entries are made. Space on the cards is provided for entering the amounts of factory and general expense which are charged against the job or department in accordance with the method in vogue for distributing such charges. On completion of the job, or at time intervals for a department, the total cost is summed up and the card is filed away for reference.

Labor time and material devoted to indirect service in the establishment, which will form portions of the factory and general expense, are assembled in similar manner for charging against appropriate accounts. A list of these accounts is given below.

After the data have been drawn off on job or special service sheets, the time cards are passed on to the pay roll department where the proper entries are made to facilitate the making up of the pay roll at regular intervals. This department carries its own charge account, covering the entire establishment. In a similar manner the material cards, or their duplicate records, are used in the stock accounts, amounts issued on the several jobs being entered as credits for checking against materials received.

These simple statements do not express the importance or complexity of the task of distributing labor costs to the various divisions which make up the sum total of plant activities. The bookkeeping part is simple enough, but it requires care and judgment in laying out the plan of classification which will assign labor and service costs in a rational manner. It has been remarked before that the direct charges should be made to cover as large a portion of the total as possible, in order to reduce the amount to be distributed by proportional methods. With a well-developed system, it is practicable to assign a considerable portion of the salaries and wages of the superintending staff, tool room labor, repairs on machinery, inspectors, timekeepers, and other groups of workers, either direct to jobs when these are large undertakings calling for the entire attention of the plant for stated periods of time, or to groups of machines for which hourly machine rates may be calculated with accuracy, thus making more specific the charges to jobs. After such charges have been made, the unassigned portions of the service expense

are thrown into the factory expense group for distribution on the proportional plan.

To provide for this semi-direct allocation of expense there must be carried a set of charge accounts within the manufacturing department, intermediate between the direct job accounts and the factory expense accounts. This should include:

Superintendent, foremen, etc.
Shop engineering.
Planning department force.
Inspection.
Tool room.
Time keepers.
Move material gang.
Direct machine repair and special machine set-up.

This system permits of the direct charging of a considerable portion of the general factory service against jobs or departments, and therefore of more accurate cost analysis. The method of procedure is indicated more clearly by the accompanying form for summarizing the accounts, with the note attached thereto.

Other charge accounts in the manufacturing department, for recording labor and other expense items not covered in the above, and which make up true *factory expense*, to be charged to jobs by the proportional scheme, are:

Power, heat, and light.
Plant service—janitor, etc.
Building repair.
Equipment repair, general.
Materials handling, general.
Miscellaneous indirect labor.
Insurance, machinery.
Insurance, buildings.
Taxes, machinery.
Taxes, buildings.
Depreciation, machinery.
Depreciation, buildings,
Others as conditions may dictate.

For distributing materials and supplies to either jobs or departments a parallel set of accounts may be carried, against which material and supplies will be charged, or provision made for such entries on the same forms with labor costs.

______CO. MONTHLY SUMMARY — SEMI-DIRECT ACCOUNTS ______1923

ITEM \ ORDER NO.	TOTAL OF ACCOUNT	No. ___	No. ___	No. ___	No. ___	No. ___	No. ___	No. ___	No. ___	TO OFFICE	TO SHIPPING	TO FACTORY EXPENSE
SUPERINTENDENT												
FOREMAN A												
FOREMAN B												
FOREMAN C												
SHOP ENGINEER												
PLANNING STAFF												
INSPECTORS												
TOOL ROOM LABOR												
MOVE MATERIAL GANG												
MACHINE REPAIR MEN												
TIMEKEEPERS												
ETC.												

FIG. 31.—Form for allocation of certain items of expense.

This is used for convenience in bringing together the indirect labor accounts which are susceptible of direct allocation, in part, to jobs or departments. The sheet may be ruled for as many jobs as conditions make desirable. *Shipping* and *office* are service activities included because of desirability of finding costs for them separately, but the amounts entered in those columns should be included also in the residue entered against *factory expense*. A primary account is carried for each item of indirect labor entered in this summary, from which the amounts to be entered under the job orders are drawn.

When the department costs are desired for continuous process industries, or when costs are to be allocated first to machine groups and afterwards to jobs by the "machine-time" method, the same form of summary sheet may be used. In that case the column headings are departments instead of job order numbers; or they may be separate machines or machine groups Such a plan makes it possible to fix machine hour rates in accordance with actual working conditions during the period covered

The residue charged into *factory expense* is totaled with the other divisions of expense, power, plant service, insurance, taxes, depreciation, miscellaneous labor, and other forms of expense, which must be distributed later by some proportional plan.

To provide for an analysis of selling expense, accounts should be carried as follows:

Sales office.
Sales agencies—one for each branch office.
Salesmen—salaries, commissions, expenses.
Advertising.
Freight and express.

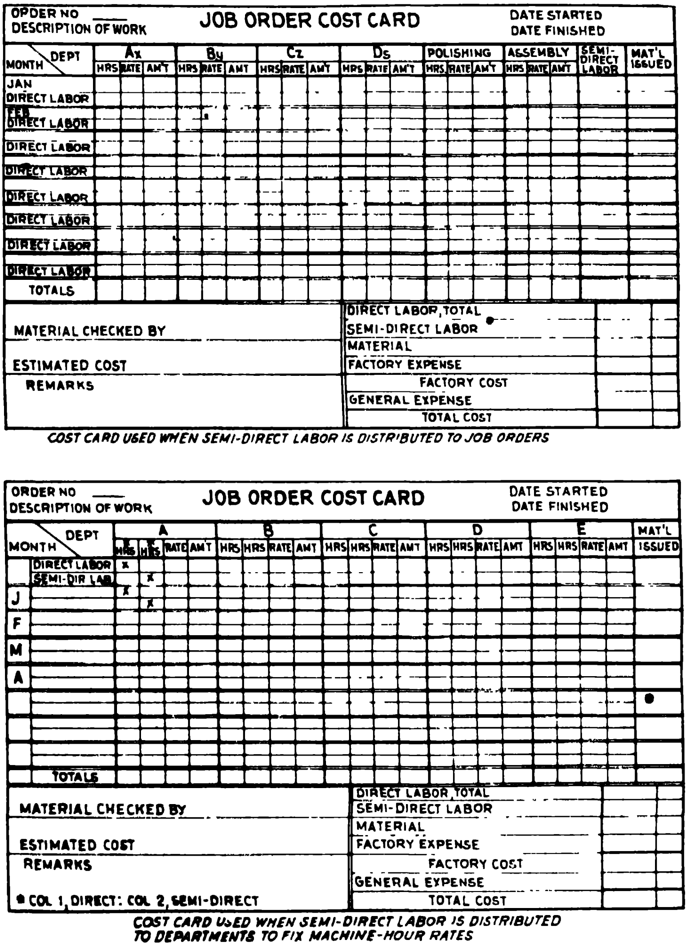
A suitable distribution of the general expenses is secured by a set of accounts which includes:

Salaries, general officers.
Clerical salaries.
General office—furniture and supplies.
Engineering and design.
Drafting office—salaries and supplies.
Experimental and development account.
Transportation—general travel.
Garage.
Legal expense.
Communications—postage, telephone, telegraph.
Buildings—repairs, maintenance, and depreciation.
Patents.
General property not employed in direct plant activities.
General police and watch service.
Miscellaneous.
Others as conditions may dictate.

The final step is to assemble all items of cost on the cost card. The accompanying form illustrates such a card, adapted to manufacturing by the job order method.

Segregation of expenses under these numerous accounts might not be necessary if the only consideration were that of securing information on the amounts to be distributed as factory and general expense, or overhead. But herein lies the difference between the traditional and the modern methods of cost accounting. Detailing of expenditures is necessary for a proper cost control. In the evolution of management methods attention was directed first to the accounting of labor and materials employed in direct operations. Investments and sales expense have also been accorded careful scrutiny. But the great body of expenditures which fall into the groups designated as "overhead" has been given scant attention. The control of these items is an important

task for the cost accountant, and is a fertile field for intelligent study. The manufacturer of the present day is confronted with the serious problem of maintaining himself in the markets of the world. To meet competition only one recourse is open to him, and that is to reduce production costs. This must be done



ORDER NO ___ DESCRIPTION OF WORK — JOB ORDER COST CARD — DATE STARTED / DATE FINISHED

MONTH \ DEPT	Ax			By			Cz			Ds			POLISHING			ASSEMBLY			SEMI-DIRECT LABOR	MAT'L ISSUED
	HRS	RATE	AMT	HRS	RATE	AMT	HRS	RATE	AMT	HRS	RATE	AMT	HRS	RATE	AMT	HRS	RATE	AMT		
JAN DIRECT LABOR																				
FEB DIRECT LABOR																				
DIRECT LABOR																				
DIRECT LABOR																				
DIRECT LABOR																				
DIRECT LABOR																				
DIRECT LABOR																				
DIRECT LABOR																				
TOTALS																				

MATERIAL CHECKED BY	DIRECT LABOR, TOTAL		
	SEMI-DIRECT LABOR		
ESTIMATED COST	MATERIAL		
	FACTORY EXPENSE		
REMARKS	FACTORY COST		
	GENERAL EXPENSE		
	TOTAL COST		

COST CARD USED WHEN SEMI-DIRECT LABOR IS DISTRIBUTED TO JOB ORDERS

ORDER NO ___ DESCRIPTION OF WORK — JOB ORDER COST CARD — DATE STARTED / DATE FINISHED

MONTH \ DEPT		A				B				C				D				E				MAT'L ISSUED
		HRS*	HRS*	RATE	AMT	HRS	HRS	RATE	AMT	HRS	HRS	RATE	AMT	HRS	HRS	RATE	AMT	HRS	HRS	RATE	AMT	
	DIRECT LABOR	x																				
	SEMI-DIR LAB		x																			
J																						
F																						
M																						
A																						
	TOTALS																					

MATERIAL CHECKED BY	DIRECT LABOR, TOTAL		
	SEMI-DIRECT LABOR		
ESTIMATED COST	MATERIAL		
	FACTORY EXPENSE		
REMARKS	FACTORY COST		
	GENERAL EXPENSE		
* COL 1, DIRECT: COL 2, SEMI-DIRECT	TOTAL COST		

COST CARD USED WHEN SEMI-DIRECT LABOR IS DISTRIBUTED TO DEPARTMENTS TO FIX MACHINE-HOUR RATES

FIG. 32.—Cost cards.

despite adverse influences in the form of high wages, a high material market, and a high fuel market. The result will be accomplished only through the exercise of a superior quality of management, dedicated to the proposition that every phase of operating activity is to be subjected to most careful scrutiny and

brought under control. Exact information is the basis of control. It is a fortunate circumstance that the National Association of Cost Accountants is devoting much of its attention to the study of the important question of "expense."[1]

In the preceding chapter considerable attention was devoted to graphical records. It should not be overlooked that this form of aid to management is closely associated with cost data. Performance in the meeting of cost standards is readily indicated by graphical charts, and much may be accomplished by their use. Information presented in this form is easily understood and should be placed where every worker and every official in the establishment may see the results.

Based mainly on combined cost and sales accounts is the Statement of Operations of the enterprise, covering some stated period of time, either the month or the year. It should be gotten out monthly for the guidance of the management. Along with the monthly statement should be shown the cumulative figures for the fiscal year, and also figures for the preceding twelve months as a moving annual total according to the idea of the *Z*-chart described in the preceding chapter. The following is an illustrative statement for the month alone.

STATEMENT OF OPERATIONS

	For Month Ended ——30, 192–		Cumulative for Year up to——30, 192–
Sales		$62,500 25	
Less returns.	$ 1,300 50		
Cash discounts. . . .	2,400.00		
Other allowances .	125 40	3,825 90	
Net sales.		$58,674 35	
Cost of goods sold. . . .	$47,840 65		
Additions through abnormals;			
Development, prior .	1,250 00		
Tool room, debit. . .	324.30	48,766 35	
Net income from operations		$ 9,908 00	

[1] See article," Managerial Control through Costs," *Management Engineering*, February and March, 1923, by J. P. JORDAN, President of the Association.

STATEMENT OF OPERATIONS (*Continued*)

	For Month Ended —30, 192-		Cumulative for Year up to—30, 192-
Other income:			
Cash discounts taken...	$1,490 85		
Interest received........	82 70		
Miscellaneous	42.60	1,616 15	
Total net income		$11,524 15	
Deductions from income:			
Interest paid.........	$ 122 40		
Miscellaneous........	63 55	185 95	
Net profit from operations........		$11,338 20	
Deduct quarterly dividend	$8,000 00		
Deduction for transfer to reserve accounts	1,600 00	9,600.00	
Balance trans. to surplus		$ 1,738 20	
Surplus beginning of period		87,420 42	
Surplus at end of period........		$89,158 62	

The foregoing discussion has been directed toward conditions in the machine manufacturing industry. This has been so because of obvious advantages which come from confining illustrations to a specific line. With proper modifications, however, the principles outlined may be applied to any activity.

An interesting development has been going on in the standardization of railway accounts under the direction of the Interstate Commerce Commission. The valuation of railway properties, now nearly completed, furnishes the basis for effective supervision. To make secure the benefits of that undertaking it has been necessary to formulate plans for an accounting practice, uniform for all roads, and calculated to give an accurate record of expenditures classified so as to show operating costs in the several departments. The following outline gives the main features of the system.

Detailed instructions were issued by the Interstate Commerce Commission in May, 1914, prescribing the "Classification of Operating Revenues and Operating Expenses of Steam Roads," and also the "Classification of Investment in Road and Equipment of Steam Roads." These instructions are published in pamphlet form by the Government Printing Office, from which

they may be obtained. In the form now in force they are designated as the "Issue of 1914."

The *Operating Revenue* accounts are classified under four general accounts, namely:

I. Transportation—rail line.
II. Transportation—water line.
III. Incidental.
IV. Joint facility.

Under the first are 16 primary accounts, numbered serially from 101. They are: freight, passenger, excess baggage, sleeping car, parlor and chair car, mail, express, other passenger-train, milk, switching, special service train, other freight-train, water transfers-freight, water transfers-passenger, water transfers-vehicles and live stock, water transfers-others.

Under the second are 8 primary accounts, numbered serially from 121. They are: freight, passenger, excess baggage, other passenger service, mail, express, special service, other.

Under the third are 13 primary accounts, numbered serially from 131. They are: dining and buffet, hotel and restaurant, station, train and boat facilities, parcel room, storage-freight, storage-baggage, demurrage, telegraph and telephone, grain elevator, stockyard, power, rents of buildings and other property, miscellaneous.

The fourth includes as a credit item the carrier's proportion of revenue collected by others in the operation of joint tracks, yards, terminals, and other facilities, and, as a debit item, that portion of the corresponding revenues collected by the carrier but which is creditable to other companies.

Operating Expense is classified under eight general accounts, namely:

I. Maintenance of way and structures.
II. Maintenance of equipment.
III. Traffic.
IV. Transportation—rail line.
V. Transportation—water line.
VI. Miscellaneous operations.
VII. General.
VIII. Transportation for investment.

Under the first are 79 primary accounts numbered serially from 201. The complete list will not be repeated, but it includes superintendence, which covers pay of all officials in that department from the vice president down to the last clerk and porter having to do with way and structures; the roadway, bridges, ties, rails, ballast, water stations, all buildings for whatever purposes, elevators, wharves and docks, power transmission and distributing systems, and all service rendered in the care of the property. Each type of property has two accounts—one on the property itself and one for depreciation on the same.

Under the second are 37 primary accounts numbered serially from 301. They include superintendence in the motive power department as does the list under the first general account; locomotives and all kinds of cars in separate accounts; shop machinery, power plant machinery, work equipment of all kinds; and various expenditures having to do with equipment and its use, such as insurance and miscellaneous expense. Each item of rolling stock has three accounts—one the equipment itself, one depreciation on the same, and one retirements to cover actual withdrawal from service.

Under the third come 9 primary accounts numbered serially from 351. They are superintendence, outside agencies, advertising, traffic associations, fast freight lines, industrial and immigration bureaus, insurance, stationery and printing, and "other expenses." This general account corresponds to the sales department account in a manufacturing plant.

Under the fourth come 50 primary accounts numbered serially from 371. They include all operating expense accounts involved in the actual moving of trains, such as superintendence, pay of train crews, dispatchers, yard men, signal operation, fuel and supplies of all kinds, insurance, and damage claims. It corresponds to the operating department of a manufacturing plant.

The fifth includes 3 primary accounts: operation of vessels, operation of terminals, and incidental—numbered 431, 432, and 433.

The sixth includes 6 accounts: dining and buffet service, hotels and restaurants, grain elevators, stockyards, producing power sold, other miscellaneous expenses—numbered 441 to 446.

The seventh includes 12 primary accounts: salaries and expenses of general officers, same for clerks, general office supplies, law expense, insurance, relief department expenses, pensions,

stationery and printing, valuation expenses, "other expenses," general joint facilities, Dr. and Cr.—numbered from 451 to 462.

The eighth is an account covering expense to the road of transporting, on transportation trains, men and material for construction work. Credits on this account are concurrently charged to property investment accounts.

Expenditures for *Investment in Road and Equipment* are classified under three general accounts, namely:

I. Road.
II. Equipment.
III. General expenditures.

Under the first are 47 primary accounts, numbered from 1 to 47. They cover all classes of new construction on the same items of property included under Maintenance of Way and Structures as mentioned under Operating Expense.

Under the second are 8 primary accounts, numbered from 51 to 58. They cover steam locomotives, other locomotives, freight cars, passenger cars, motor equipment of cars, floating equipment, work equipment, and miscellaneous equipment.

Under the third are 7 primary accounts, numbered from 71 to 77. They are: organization expenses, general officers and clerks, law, stationery and printing, taxes, interest during construction, and "other general expenses."

It is understood that these expenditures represent additional investment in the transportation facilities of the road. The amount is to be added to the total valuation of property as that property existed at the time when the accounting system was put into effect, which was July 1, 1914.

ELECTRIC UTILITIES ACCOUNTS

The need of uniformity in the accounting practice of electric utilities has led to the formulation of a system of classification of accounts, the general features of which are quite generally observed. The Wisconsin State Utilities Commission detailed the plan in 1908. With some modifications in details it is substantially the same as the system adopted later by the National Electric Light Association.[1]

[1] For a complete description of the system see EDWARDS' "Electric Light Accounts," McGraw-Hill Book Co. Also the Report of the Wisconsin Commission.

The prescribed form of report under the Wisconsin regulation shows the main elements of the classification, and it is reproduced in full below.

INCOME ACCOUNT FORM FOR REPORT, ALL CLASSES

Operating Revenues		
Commercial lighting earnings	$xxxxxxxx	
Municipal contract lighting earnings	xxxxxxxx	
Commercial power earnings	xxxxxxxx	
Municipal power earnings	xxxxxxxx	
Sales of electric current to other public utilities	xxxxxxxx	
Miscellaneous earnings from operation	xxxxxxxx	
Total operating earnings		$xxxxxxxx
Operating Expenses		
Power	$xxxxxxxx	
Transmission and transformation	xxxxxxxx	
Storage	xxxxxxxx	
Distribution	xxxxxxxx	
Consumption	xxxxxxxx	
Commercial	xxxxxxxx	
General	xxxxxxxx	
Undistributed	xxxxxxxx	
Total of above items	$xxxxxxxx	
Depreciation	$xxxxxxxx	
Contingencies (extraordinary)	xxxxxxxx	
Taxes	xxxxxxxx	
Total operating expenses		$ xxxxxxxx
Net operating revenue or deficit		$xxxxxxxx
Non-operating revenues		$xxxxxxxx
Gross income or deficit		$xxxxxxxx
Deductions from gross income		
Interest on funded debt	$xxxxxxxx	
Interest on real estate mortages	xxxxxxxx	
Interest on floating debt	xxxxxxxx	
Contractual sinking fund requirements	xxxxxxxx	
Amortization reserve requirements	xxxxxxxx	
Miscellaneous deductions	xxxxxxxx	
Total deductions		$xxxxxxxx
Net income or deficit		$xxxxxxxx

INCOME ACCOUNT FORM FOR REPORT, ALL CLASSES (*Continued*)

Disposition of Net Income		
Preferred stock dividends	$xxxxxxxx	
Common stock dividends	xxxxxxxx	
Appropriations to Municipal Funds	xxxxxxxx	
Other payments from net income	xxxxxxxx	
Total		$xxxxxxxx
Surplus or deficit for the year		$xxxxxxxx

It should be noted that the item "Non-operating Revenues" comes from the primary accounts of Merchandise Sales, Wiring and Installation Work, Rents from all properties, Interest on Deposits, Interest from Investments, Appropriations from Municipal Funds (municipal plants only), and Miscellaneous. Each of the other general accounts included in the report is divided similarly into various primary accounts, somewhat as in the case of the railroad accounts.

A standardized form of balance sheet has also been adopted, although not in so fixed a manner. Practice under the National Electric Light Association plan differs in titles of items from the Wisconsin forms in several respects. The following is a typical example, summarized in part:

ASSETS		LIABILITIES	
Property and Plant		Capital Liabilities	
Cost beginning of year	$xxxxxxxx	Capital Stock, preferred	$xxxxxxxx
Changes during year, new construction	xxxxxxxx	Capital Stock, common	xxxxxxxx
Cost close of year	xxxxxxxx	Funded Debt	xxxxxxxx
Treasury Securities		Mortgage Liabilities	
Treasury Stock	xxxxxxxx	Real Estate Mortgages	xxxxxxxx
Treasury Bonds	xxxxxxxx	Other Mortgages	xxxxxxxx
Investments		Current Liabilities	
Stocks and Bonds of other companies	xxxxxxxx	Notes and Bills Payable	xxxxxxxx
		Accounts Payable	xxxxxxxx
Other investments	xxxxxxxx	Interest matured	xxxxxxxx
Reserves		Dividends unpaid	xxxxxxxx
Renewal reserve fund	xxxxxxxx	Deposits	xxxxxxxx
Sinking, Amortization, and special	xxxxxxxx	Sundry current accounts	xxxxxxxx
Current Assets		Accrued Liabilities	
Cash	xxxxxxxx	Interest unmatured	xxxxxxxx
Notes and Bills Receivable	xxxxxxxx	Insurance and Taxes accrued	xxxxxxxx
Accounts Receivable		Dividends accrued	xxxxxxxx
Materials and Supplies	xxxxxxxx		
Sundry current assets	xxxxxxxx		
Prepaid Accounts		Reserve Liabilities	
Prepaid insurance, taxes, and interest	xxxxxxxx	Depreciation	xxxxxxxx
Sundry accounts	xxxxxxxx	Sinking, Amortization, and special	xxxxxxxx
Open or Suspense Accounts		Open Accounts	
		Surplus	xxxxxxxx
Total	$xxxxxxxx	Total	$xxxxxxxx

THE CAPITAL ACCOUNT

The treatment of the question of costs can not be considered as complete without a discussion of capital charges in manufacturing enterprises. It is an element of commanding significance for the railroads and other public service corporations, but custom has, in the past, eliminated it from cost analyses in the practice followed by privately owned and controlled industries.

In the commonly accepted philosophy of costs, the "total cost" of product is the grand total of all expenditures of the company in the conduct of its business, including a depreciation allowance made for the safeguarding of capital assets, but with the significant omission of returns on investment. Out of what is termed "profit" must be paid both interest on funded indebtedness and dividends on stock. Interest on notes payable and on temporary bank loans have been included in the general expense item, but the permanent investment has been disregarded. It has been accepted as a policy by those having to do with the control of investments that whatever was left from income after the payment of all other obligations was available for the payment of dividends or for further investment according as the directors should decide. From the legal standpoint that is a correct interpretation.

But from the standpoint of the administration of producing enterprises it is not sound philosophy or a wise policy. Capital is one of the production factors and is entitled to a wage, just as labor is entitled to a wage. The wage paid to capital is just as truly an element of cost as is that paid to labor. Until the payment has been made, as interest on bonds and dividends to stock, there can be no true determination of "profit and loss."

The prevailing practice is unwise as to policy because it carries into the accounts an element of uncertainty, which is likely to result in suspicion. It tends to cloud the issue and make more difficult the establishment of coöperative relations between management and wage earners. It stands, therefore, in the way of efficient production. True coöperative measures are impossible so long as there is any lack of frankness and open dealing on the part of either party to the arrangement. The time has come in this country when labor is expecting a fuller recognition of its place in the industrial program. Whether or not it will demand a larger part of the returns from industry depends upon the extent of its information as to what it is

contributing to production. It is important that that information be accurate and complete, which it cannot be unless there is an accounting of returns to bona fide investments.

It is fully recognized that an advocate of this change in practice has many weighty objections to meet. In the absence of franchise or monopolistic rights accorded to public service corporations, the company must take its chances in a competitive market and operate on a variable income. Those who invest assume a risk and should be entitled to returns which are commensurate. Any established scale of dividend payment entering into a costing plan of the kind suggested must be high enough to cover the risk in a reasonably adequate manner. After all, it is not so much a question of the exact amount paid as it is of accuracy in the final determination of profit.

There is involved, also, the practice of witholding dividends and reinvesting the surplus, which has been the means of building up many great industries. This, however, would not be affected by a plan of including dividends in cost of product. The dividend would not necessarily be paid in cash. If reinvested, every one would then know how much of the added capital assets came from dividends retained in the business and how much from true profits. Some stockholders might not want that to be known when the time came for declaring stock dividends to cover enhanced value of the physical property, but it would be in the interests of accuracy, and accuracy in accounting is a primary requisite in the conduct of modern business.

EXERCISES FOR PART II

1. A group of men has under way plans for organizing a corporation to engage in a manufacturing enterprise. The company activities are likely to extend into several states, and it may need to engage in transportation activities incident to the development of its properties, as also to mine coal or produce oil on its land holdings. Its head office is to be in one of the central states.

As chairman of the organizing committee, prepare a draft of the statement of objects of the corporation, to be submitted to the state corporation commissioner in application for a charter, and make written recommendations as to the state in which you propose to incorporate, giving reasons for your choice.

Assume the capital stock authorized to be not less than $500,000.

Make recommendations, also, on such matters as time and place of stockholders' meetings, regular meetings of directors, and other major points covered in the by-laws of the corporation.

2. Write a brief article (300 to 500 words) on the rights and liabilities of stockholders.

3. Write a brief article (not over 300 words) on the liability of partners in a general partnership.

4. Prepare a complete contract for some form of construction job. Specifications need not be written, but will be referred to as if in existence and so "included by reference" in the contract. Instructions to bidders, the advertisement, and form of proposal will be prepared on the assumption that the job is to be let on competitive bidding. Approved jobs are: construction of a section of highway, a block of paving, a line of sewer, a water purification plant, a bridge, a building, or an electric power transmission line; the building of a specified number of machines or any article according to design and specifications already prepared; laying of a pipe line of specified size, for which plans have been drawn; sinking of a mine shaft with specified method of timbering.

5. Draw a complete organization chart for a company engaged in one of the following activities: a metal working plant which shall include either a foundry or drop-forging department, machine shop, assembly department, planning department, and the usual auxiliary departments; a steel mill, including blast furnace and rolling mill branches; a cement mill; a structural steel plant including an erecting department and a fabricating shop; the motive power department of a railroad; the operating department of a railroad, with a well-developed plan of divisional organization; an oil refinery; a metal mining company with ore treating and smelting departments; or a large steam-electric power station.

6. Make a complete analysis of the following balance sheet of a manufacturing company, according to the methods developed in Chapter VIII.

Assets		Liabilities	
Plant: Land	$ 24,000	Capital stock, common	$ 400,000
Buildings	188,652	Capital stock, preferred	310,000
Equipment	336,864	Bonds	400,000
Raw material on hand	207,076	Accounts and bills payable	242,915
Stock, finished and process	320,989	Notes at bank	20,000
Bills and accounts receivable	295,405	Bond interest due	2,435
Cash on hand	86,425	Depreciation reserve	48,000
Sundry investments	9,095	Other reserves	77,773
Patents	92,000	Surplus	59,383
Total	$1,560,506	Total	$1,560,506
Total sales for the year	$1,710,600		

7. Time, machine, and job order records in a manufacturing plant show the following facts: John Smith, a machinist, during the week of March 6 to 12, on Monday produced 10% over standard; Tuesday, 15% below on account of tool trouble; Wednesday, 25% below through lack of material; Thursday, 40% low because of half holiday; Friday, 20% over standard; Saturday, made exactly standard record.

An automatic screw machine during same week, on Monday ran full time; Tuesday lost 1 hr. waiting for set-up man and the operator was absent half day; Wednesday ran full time; Thursday half time account of holiday; Friday lost 3 hr. account of no orders; Saturday shut down after two hours for repairs. Shop runs 8 hr. per day, 5 hr. on Saturday.

An order for 200 change speed gears was given the following schedule. Issue of stock Monday January 15, first operation to begin January 16; second operation January 23; third operation, February 8; fourth operation, February 19; fifth operation, March 1; finish, March 6. It was held up on the third operation for 3 days on account of the gear-cutting machine developing trouble. The workman on the fourth operation was absent 2 days, but made up 1 day on the schedule, making the job 4 days behind on reaching the fifth operation. The job is checked up on March 3.

Prepare Gantt charts for the three forms of record. Draw up the charts on standard size paper 8½ by 11 in. with regular ruling—Man Record and Machine Record for two-week period and Progress of Order Chart for three months—although the data given will fill only one line on each for a portion of the time.

8. Production records in a cement mill are as follows:

Output in Barrels per Month	1921 Bbl.	1922 Bbl.
January	108,000	96,500
February (Down for repairs 10 days in 1921)	48,600	87,000
March (Bad material, 1922)	94,800	72,300
April	102,000	104,000
May (Kiln trouble 1921)	94,700	106,100
June	104,000	97,900
July (Down for repairs 14 days in 1922)	103,000	52,600
August	107,500	106,800
September	100,400	104,700
October	106,200	99,300
November (Breakdown in quarry 1922)	98,800	82,100
December	107,400	105,900

Prepare a Z-chart for 1922 operation. Standard output 4,000 bbls. per day.

9. A concern employing about 600 men is having trouble holding the workers. An investigator delegated to look into the matter finds a labor turnover of 160% annually, most of which is among the semi-skilled workers, in which group the average cost of breaking in a man is $45. The normal output per employee should be $4,500 annually, but it is found to actually be 15% below that figure. The scale of wages paid is fully up to the standard for the locality. Industries in the community employ a total of some 10,000 men of similar qualifications, but there is no apparent shortage of labor as a whole. The spirit of the men in the plant is friendly enough, but there seems to be no incentive to good performance. The investigator reports that foremen are working hard but do not have definite ideas of standard output; neither do they have time to study methods.

Prepare a report showing a plan of procedure to improve conditions. First make an estimate of the saving that would be effected if the labor turnover could be cut to 25% and output increased 10% over present performance. Based on this saving, what would you recommend to the management as an amount which might properly be spent annually instituting better practices? Refer to any type of industry desired, such as a structural steel plant with erecting gangs, machine manufacturing plant, textile mill, oil refinery, railroad repair shops or any other department of a railroad. (Remember that in increasing output the saving made is measured by profit on the output, not by the increased output itself.)

10. Cost data applying to the 200 change speed gears being made on the schedule specified in the third section of exercise 7 are as follows:

Material:

200 cast-steel gear blanks, purchased, 3 lbs. each at 15 cts., $90.

Direct labor:

In January, 106 hrs.; February, 164 hrs.; March, 72 hrs.; hourly rate, 62 cts. per hour for all excepting 136 hrs. in February when the job was on the gear-cutting machines, for which the rate was 68 cts (Calculate the average rate for February.)

Service to be allocated on semi-direct basis will be determined from the several charge accounts, for which the monthly summary sheets will be prepared. These accounts give the following facts:

Item	Total of account			To charge on this order			To factory expense		
	Jan	Feb.	Mar.	Jan.	Feb.	Mar	Jan.	Feb.	Mar.
Supt.	$250 00	$250.00	$250.00	$6 20	$2 50	$7.50	$85.50	$96.00	$122.25
Foreman	175 00	175 00	175 00	9 00	6.50	8.00	15.00	12.50	18.00
Planning Dept	400 00	400 00	400.00	18 00	2.00	6 00	25 00	40 00	30.00
Inspector . . .	150 00	150 00	150 00	2 00	4.00	6 00	15 00	12.00	14.00
Move. mat'l	90 00	90 00	100.00	1.60	1.00	1.50			
Time keeper . . .	100 00	100 00	100.00	2.50	2.50	2.50			

Prepare the three monthly Summary sheets according to the outline given at page 295. Assume two other foremen, not concerned in this job but each with the same charges going to factory expense. Also tool room and repair gang carrying a total of $100 per month to the factory expense account.

Factory Expense.—The charge accounts in this group show the following totals for the shop as a whole, annually:

Power, heat, and light	$8,000
Plant service, general	1,800
Building repair	500
Equipment repair	800
Materials handling, general	1,000
Indirect labor, miscellaneous	5,000
Insurance, total	750
Taxes, total	2,000
Depreciation, total	4,000
Miscellaneous expense	1.500

In distributing factory expense, either of two methods is possible. The total of the general annual accounts may be reduced to the amount per month and the expense distributed for each month separately, or the monthly amounts from the semi-direct accounts may be averaged and reduced to the annual total and the total factory expense distributed on the annual basis. The first is more accurate, especially for a job-order establishment where conditions are liable to change, but it involves more work. Judgment must determine procedure.

Factory expense will be distributed on the basis of labor hours. The total of direct labor hours for the plant is 244,500 for the year ending February 28. This job has 342 hours.

Sales and General Expense.

The primary charge accounts show the following annual expenditures:

Sales office, salaries and supplies	$ 8,900
Salesman	3,000
Advertising	1,000
Freight and express	1,500
General officers, salaries	15,000
Other office expense	6,000
Design, drafting, and development	8,200
Legal expense	3,000
Transportation, total	6,500
Postage, telephone and telegraph	900
General office buildings, including insurance	800
Police and watch service	2,400
Patents	2,000
Miscellaneous general expense	3,000

General and sales expense will be distributed on the basis of factory cost. The total factory cost on plant output for the past year has been $550,000.

A job order cost card is now to be drawn up and all entries made for this order. Use the first form of card shown on page 297.

APPENDIX A

CONTRACTS

NOTE.—It is not proposed to make of this a complete treatment of the subject of contracts. The object is merely to set forth certain of the more obvious principles with which every man engaged in industrial matters should be familiar. This should be supplemented by a more extended reading of the standard works on the subject. Two such books which are especially adapted to engineering practices are Tucker's "Contract in Engineering" (McGraw-Hill Book Company), and Mead's "Contracts and Specifications" (McGraw-Hill Book Company).

An engineer should be familiar with the basic principles of the common law touching contracts and contractual obligations. Beyond these are many statutory regulations, and, even more important, a great mass of court decisions which have established the basis for the construction of contracts, through the avenues of custom and practice. In these latter realms the man whose study and experience have been limited to such brief outlines is bound to flounder and run into almost sure danger unless he avails himself of the services of a lawyer in any vital matter where legal processes are involved. It may be said that the most to be gained in this discussion is a realization of the importance of securing competent legal advice. From the actual knowledge of contracts that may be gained here, however, the engineer should be enabled to prepare specifications and the general provisions of engineering contracts in a manner that will make them harmonize with legal principles. If he can do this, he will have accomplished much. In general, the engineer's work is creative rather than interpretative and he should approach the subject with that fact in mind.

CONTRACTS DEFINED

The definition of a contract is important. Several are given for the purpose of bringing out the various points.

A **contract** is an agreement between competent parties, enforceable at law, whereby each acquires a right to what is promised by the other.—Tucker.

A contract is an agreement in which a party undertakes to do or not to do a particular thing.—Chief Justice Marshall.

The term "agreement" is very frequently used in place of "contract" in engineering engagements, and Mead, in his book on "Contracts and Specifications," makes the following statements:

An agreement is the expression of two or more persons of a mutual intention to affect the legal relations of those persons. The term is broader than the term *contract* and may include:

1. An agreement resulting in a contract. This is an agreement which directly contemplates the creation of obligations.

2. An agreement immediately concluded which creates no obligation. For example, conveyances of land without covenants; gifts; sales and delivery of chattels for cash without warranty, etc. These are sometimes called *executed contracts.*

3. An agreement concluded, with incidental or remote obligation. For example, marriage, a settlement of property in trust, etc.

An executory contract is a legal obligation created by agreement and enforceable by an action at law; it is one in which at least one of the parties has something yet to do.

A bilateral contract is an executory contract consisting of an express promise of one legal right given in exchange for a counter promise of another legal right.

An express contract is a bilateral contract either oral or written, all of whose terms are accepted.

An unilateral contract is a half executed, half executory contract, consisting of an express or inferred promise of one legal right for another legal right.

An inferred (or implied) contract is an unilateral contract where either the act of acceptance, or both the act of acceptance and the promise offered are inferred.

A quasi-contract is a legal obligation created by pure implication of law. It is not a contract but may be enforced by legal action. (Example: recovery of value of services after same have been requested without express terms.)

A void agreement is one which creates no obligation.

A voidable contract is one whose obligation is not binding upon one party to the agreement, at his election.

The type of contract with which the engineer has most to do may be styled the *express executory contract.* It is to it that the definitions of Tucker and Chief Justice Marshall apply, as first given. It may be of either of two kinds:

1. Contract *under seal,* or *specialties.*

2. Contract not under seal, or *parole* contract. Under the common law, the following contracts must be under seal:

a. Gratuitous promises.

b. Contracts with such corporations as have that provision in their charters.

c. Deeds and mortgages.

d. Bonds.

In many states, however, statutes have changed this requirement, so that one must not be guided entirely by these statements.

A parole (or parol) contract is one not under seal. The term "parol" is used in certain connections to distinguish an oral from a written statement.

In contracts, however, the term is used as stated. The vital point at issue is that even in a written contract, if not under seal, consideration must be proved. The seal in its original sense evidenced consideration and further proof is not necessary.

CONTRACT ESSENTIALS

There are four essential elements in every contract that fulfils the definitions that are accepted as being accurate. The provision that a legal contract must be one enforceable at law has made it necessary to prescribe certain conditions that must be met. In this, court practice has determined the forms, and in the interests of justice there must be established bases on which may be tested the various agreements that people enter into in order to establish the facts as to the true intent of the parties, as well as to prevent the ignorant and the unwary from being imposed upon. These elements are common sense provisions, natural to every normal honest person in his dealings with others. They are:

1. The parties must be competent to contract.
2. The subject matter of the contract must be lawful.
3. There must be a valuable consideration; *i.e.*, each party must give or promise something that he has the privilege of keeping or not doing.
4. There must be mutual assent or agreement on the subject being contracted on; a true meeting of the minds on the exact point at issue.

For certain kinds of contracts another is required:

5. The contract must be in writing.

Competent Parties.—This is a matter of definition and fixed statutes. In general, anyone may enter into agreements or contracts, but in the legal sense exceptions are made in the cases of persons under twenty-one years of age, married women in certain kinds of contracts, lunatics, and drunken persons. The disability of married women has been removed in many states under more recent enactments.

In dealing with persons coming in this list, it is to be remembered that agreements made are in many cases voidable, especially by infants. This makes it incumbent upon one having to deal with them to investigate carefully into the exact status of the persons in question under the laws of the particular state where the contract is to be made. As regards dealing with lunatics or drunken persons, it is to be observed that the main issue is as to the ability of such parties really to come to a genuine agreement. It is likely that the supposed contract is void because of failure to comply with the fourth condition or essential, that of mutual agreement.

In the preparation of the usual form of contract, the expressed executory type, it is universal practice to start with an exact definition or description of the parties, thus obviating all difficulties in identifying the status of each. With this matter presented clearly at the outset, there is slight excuse for anyone who finds himself in trouble in this respect after having neglected to investigate with ordinary care and caution into the legal status of the other party with reference to his personal competency, or authority to act in case he is acting as agent for another. A much used opening clause runs as follows:

This agreement made and concluded this................day of ...., A. D., 19......, by and between ....(owner, corporation, agent designated by name), of the City of.............................., County of........................., State of.................., party of the first part, and........................ . . .(name as before), of the City of . ..., County of ...., State of............. ....., party of the second part.

Beyond this introductory statement it is always wise to make a further stipulation as to the interpretation of terms that may be used in the body of the contract referring to the parties, and also with respect to the recognition of agents duly authorized to act for either party. The following clauses are typical:

Whenever the word *owner*, or the expression "Party of the First Part" or "First Party" are used in this contract, it shall be understood as referring to (name and describe the party).

Whenever the word "Contractor" or the expression "Party of the Second Part" or "Second Party" are used, it shall be understood to mean the person, persons, corporation, or co-partnership who has agreed to perform this contract or to his or their legal representatives.

Whenever the word "Engineer" is used in this contract, it shall be understood as referring to the engineer of the Party of the First Part, or such other engineer, superintendent, or inspector as may be authorized by said first party to act in any particular.

A contractor who has bound himself to perform work of designated character is entitled to official notification as to the identity of any superintendent or inspector, as referred to above. Until such notice has been given him, in which he may justly insist upon a written statement if the contract is written, he will be justified in disregarding instructions from anyone appearing on the job and presuming to act for the owner. This statement is made with reference to the point that the contractor has specific rights and that attempts to bind him too closely by stipulations may take away from him his status as an independent contractor and make him an agent for whose acts the owner himself cannot escape responsibility. More on this point will appear later.

Lawful Subject Matter.—The most common grounds of illegality in contracts in which engineers are likely to be concerned are (Tucker):

1. That the proposed contract violates some state or federal statute.
2. That it is contrary to the rules of common law.
3. That it is contrary to public policy.

For a full discussion of these points the reader is referred to Tucker's "Contracts." It is to be observed that ignorance of the law excuses no one, and constant watchfulness is necessary. Under the law, parties enter into contracts "at arms length," each supposed to look after his own interests. Especially, the "Lien and Labor" laws of any state or community

must be understood by those entering into construction contracts. Sunday laws sometimes bring trouble to the unwary.

The Statute of Frauds is the most important of the express laws that are of general application, and care must be observed to comply. There are many provisions coming under this heading, but the three following are of most immediate interest:

1. Contracts involving title to land must be in writing.
2. When the acts contemplated are not to be begun within a year, the contract must be in writing.
3. Contracts for sale of "goods, wares, and merchandise" in amounts of some stipulated sum, varying from $30 to $500 in different states, must be in writing. This last provision has exceptions, but the point in it all is that anyone must inform himself as to the law on the matters involved.

As to contracts opposed to common law, attention is called to the following matters which may fall under this provision.

Contracts based upon fraud are illegal and unenforceable.

Changes or alterations in a contract where one party is secured by sureties or bondsmen, without the knowledge and consent of the surety, are illegal. In order words, an agreement appearing to bind a third party cannot be enforced on that party.

As to contracts opposed to public policy, no iron-bound rules may be laid down. The courts must rule as to this, and a contractor must be guided by his own sense of right as a public citizen. Collusion in bidding is a frequent temptation and must be avoided.

Consideration.—As before, extended reading beyond the range of this discussion is necessary to secure an adequate understanding. It may be an act, a forbearance, a promise, anything constituting a legal detriment. It must have value, although the court will not inquire into the adequacy unless fraud is charged. Even then, the legality will probably rest on the other requirement of lawful matter. The abandonment of a legal right against the other party or a third party may constitute consideration. Gratuitous promises have been defined already.

Some of the most difficult propositions, or situations to be unraveled in the construction business, are met when conditions arise, subsequent to the making of the contract, that render one party unable to perform or complete his promise. A remedy often attempted is for the contractor to throw up the job and then offer to complete it for some stated addition to the contract price originally agreed upon. For such a proposition, even if agreed to by the owner, there is no consideration in law. This suggests the care that must be exercised in making alterations or additions to any contract.

In case of actually impossible consideration, and the fact is known to both parties or to the promisee alone, the contract is void. If the promiser alone knows it, he is bound and must pay damages. The main difficulty comes when performance is impossible, or impossible without financial ruin, because of unforeseen contingencies. Here the promiser is bound under the law and must comply or pay damages, however severe it may seem. In deciding the question, the court will inquire closely into the conditions and terms of the agreement, but if the promise is clear and unconditional, the rule must apply. Here is where "rules of construction" of contracts

apply, in the effort to determine the true intent and meaning of the contracting parties.

So great are these difficulties that certain precautionary measures have become almost standard. Thus in the case of structures to be built, where underground conditions that might affect the amount of work in putting in foundations are not fully known, it has become the practice to specify some normal depth for the purpose of securing comparative bids, and then to provide a scale of unit prices to cover additional work. In machinery sales contracts there is always the proviso that dates of delivery are contingent upon strikes or other unforeseen delays. In other ways the contracts usually include provisions that serve the purpose of indicating clearly a basis for adjustment of conditions as they arise and so avoid hardship by making it possible to adjudge the case on the basis of equity.

Mutual Assent.—It is self-evident that there must be an agreement on the exact terms. The cases of failure in this respect must be studied closely to distinguish between mistakes, misrepresentation, and fraud. (See Tucker, pp. 27–30.) In case mistake is proved, as to nature of transaction, as to person, or as to subject matter, the contract is void. Misrepresentation in its pure form invalidates the contract but does not give cause of action for damages. Fraud does both. It is necessary to distinguish the several elements of fraud, which are as follows:

1. False representation of a material fact;
2. Made with a knowledge of its falsity, or in reckless disregard as to whether it was true or false;
3. Made with the intention that it should be acted upon by the plaintiff;
4. And, being believed by him, the plaintiff was induced to act by it;
5. And he thereby suffered damage.

In order to secure full understanding and complete agreement on all points, certain procedure is necessary in the letting of construction contracts where competitive bids are being considered. This applies both to construction contracts of the ordinary sort and contracts for the purchase of equipment, installation, etc. In public works contracts, additional care must be taken. In most complete form these precautions include the following steps, each calling for the preparation of a written form:

1. Advertisement, giving information as to the letting.
2. Instructions to bidders, giving in detail exact information to guide those who are to bid.
3. Forms of proposal, prepared for the purpose of bringing all bids onto the same basis for comparison.

For a full discussion of these elements, see Mead's "Contracts," Chapter IX.

The importance of exercising the utmost care in all these matters cannot be overestimated. The novice is almost sure to overlook some point, or fail to stand squarely for exact conformity with instructions. He will learn from bitter experience.

EXAMPLES FOR ANALYSIS

1. (*a*) *A* was paid in advance for high-carbon steel of a specified quality, which he was to ship to *B* as soon as it could be made. Upon receiving the

metal, *B* tested it and found it was not up to specification. Therefore, he refused to accept, and sued for a return of the purchase price. Should he recover? (*b*) Suppose the metal to have been shipped by sea, by the steamship line named by the buyer, but that the vessel was wrecked and the cargo lost. In case *B* sues for a return of his money, should he win? What facts must he establish?

2. An important witness in a lawsuit is offered $500 to stay away during the trial, and does so by leaving the state. Later he seeks to enforce the contract against the attorney who made him the offer. Can he recover? Give reasons.

3. A contractor agrees to build a wall of reinforced concrete as per plan, furnishing materials. Later he refuses to furnish steel rods enough, because of their high price. Upon your objection, he finally agrees to finish as per contract, if you will give him $50 for the last rods, which you say you will do. Upon completion he sues you for the extra $50. Can he recover? Why?

4. *A* writes to *B* offering to sell him 50 bbl. of tar for waterproofing at $2.50 per barrel. On the same day, but in ignorance of this offer, *B* writes *A* saying he is in the market for 50 bbl. of tar and that he is willing to pay $2.50 per barrel for it. Without further steps, is there a binding contract between them? Was there an offer and acceptance, and a genuine "meeting of minds?"

5. *A* offers to sell a certain piece of land for $1,000. *B* makes a counter-offer to purchase for $750, but *A* declines this. Later *B* changes his mind and concludes to accept *A*'s offer to sell for $1,000 but now this is declined by *A*. Has *B* any right against *A* by which he can make *A* accept?

6. *A* and *B* have the boundry line between their lots surveyed and marked. They acquiesce in the line. Five years later *A* finds that by a mistake the line was located so that his lot is 5 ft. too narrow. Can he have the line changed?

7. A contract provided for erecting an apartment house 180 ft. high for $50,000. The structure was completed, but while $10,000 was still due on it, a satute was found forbidding the erection of any building over 150 ft. high. Thereupon the owner refused to pay the balance. What were the contractor's rights?

8. You are the inspector on construction on a building contract with power to decide whether or not the contract is being properly carried out. The main contract is in written form, in which you are designated by name as the engineer-inspector. At a certain point in the work you specify that a partition wall be built through a certain room, the same not being shown on the original construction drawing. The contractor builds the partition on your promise that he will receive additional payment on the basis of cost of material and labor employed in the extra work. Is the owner bound by the terms of this agreement? What are the principles involved?

NOTES ON CERTAIN IMPORTANT CONTRACT PROVISIONS

In the conduct of construction work under contracts, engineers frequently are obliged to interpret clauses pertaining to the extent and character of the work called for. In other instances, questions relating to the purchase or sale

of equipment are involved. With the increasing movement of engineers into the field of selling it becomes important that they should give attention to vital points in sales contracts. The following comments on current practices may thus be of significance:

In all cases where question arises as to the legality of an agreement, the tests must be applied carefully to determine if any one of the four essentials is lacking. In some instances wherein some contract element is lacking, one party may have performed in good faith the whole or part of his work, following which some fact appears invalidating the contract as a whole. The question then arises as to who bears the cost of the work performed. If the work is valueless as it stands, the question is complicated, and the performer may have to stand for loss. If the work completed has real value, then the test question is as to who is the party profiting. If the owner thus receives benefit, the contractor may sue for a fair payment on the basis of *quantum meruit*. In effect, this amounts to a recognition by the court of the existence of an implied contract, differing entirely, it may be, from the intended contract, but still binding. Cities sometimes try to hold a contractor responsible for results of work, when some person has received damage because of the carrying out of a project, such as the diverting of water from its natural channel. If such damage arises from the nature of the undertaking, and not from any fault or neglect on the contractor's part, then the latter is safe. The common proviso in contracts to the effect that a contractor is responsible for the observance of city ordinances, building regulations, etc., does not go so far as to hold him liable for the results of the matured plan on which his work is based.

The cardinal principle in construing contracts is to determine the true intent of the parties by deciding upon the meaning of the language employed as the expression of reasonable aims and in the light of established practice in the branch of activity involved.

Alterations and Extras.—Every construction contract should carry a provision that states definitely the method by which alterations may be made. Whatever the method adopted, it should be kept in mind that in essence a new condition is being created, and fully as much care must be exercised as in making a new contract. Wait urges that when material alterations are contemplated they should be plainly treated in a supplemental contract. Extras are of equal import. Wait again says, "Extras are the contractor's aim and the owner's fear." It frequently is stated in contracts that no claim for extras will be allowed unless they have been authorized and directed in writing by the engineer. In effect, that constitutes authority for the engineer to act as an agent for the owner in the matter, and is reasonably safe. It should go further, however, and specify clearly the representative of the contractor who may legally receive and act upon such matters. There is an insidious tendency at the time of letting a contract to avoid making iron-clad provisions that sensitive persons might construe as suggesting improper motives or suspicions of such motives on the part of one party. This is entirely an error. Parties contract on a free and equal basis, and each must look out for his own interests. A full statement is in the interest of clearness, necessary for a genuine agreement or meeting of the minds on the exact terms.

Payments.—In machinery sales contracts a somewhat similar case occurs in arranging times and distribution of payments, especially when there is involved the service of the manufacturer's men in erecting. For long shipments with uncertain freight service, basing the first payment on receipt of bill of lading, in effect throws the responsibility of dealing with the transportation company in case of delay or damage onto the shoulders of the purchaser. Even more surely is this done by the stating of the amount of the price in the common terms of "f. o. b. **mfr's works** with freight allowance to......................." Both of these provisions may be so definitely the policy of the manufacturer that acquiescence is necessary, but it must be understood by the purchaser that any variation must be stated in explicit terms. The writer has been able to secure variation at times, in dealing with sales representatives, usually by showing the state of the public mind on municipal deals should it happen that the first payment, "30 days after date of bill of lading," might have to be made before the actual arrival of the goods and in the face of possible loss or damage by the railroads. The point is, make the best terms one can at the time when he is on equal terms with the other party, which is when the contract is being let, and not after something has happened. It is to be borne in mind, however, that in extensive equipment manufacturing contracts it may be the part of wisdom and economy on the part of the purchaser even to go to the extent of making payment in some part before the construction work is completed and with the partially fabricated material in the plant of the manufacturer. On the other hand, if on the selling side, one wants to make sure in the case of long-deferred final payment, remembering that title does not pass until after that payment, that depreciation of the machine during operation may not exceed the amount of the early payments. Otherwise, if it becomes necessary to take possession on default of payment, one will have on his hands a machine of low value.

Agency

Reference has been made repeatedly to the acts of an agent, responsibility of principal or agent, etc. It is very necessary that the more obvious facts concerning the relationship be understood, although only a bare statement of the underlying principles will be made here.

Tucker defines agency as "the relation between two or more persons, created by a contract, express or implied, by which one undertakes with more or less discretionary power to represent another in the transaction of certain lawful acts or business."

Also, "At common law, every person who is competent to act in his own right, and for himself, may act by an agent."

Agency may be created by an express act or instrument, and under certain conditions by implication. The latter occurs under conditions of ordinary usage as established by well-known previous acts of the principal.

When one deals with an agent he must ascertain the extent of the agent's authority, at his own risk.

Certain personal and judical acts cannot be delegated to an agent.

Theoretically, an agent cannot pass on his authority to another, but in actual practice many acts may be so delegated in accordance with custom and usage.

Agent's authority, by Mechem, consists of:

1. The powers directly and intentionally conferred by the voluntary act of the principal.
2. The incidental powers which are reasonably necessary to carry into effect the main powers conferred, unless they are known to be prohibited.
3. The powers which custom and usage have added to the main powers, and which the parties are deemed to have had in contemplation at the time of creating the agency, and which are not known to have been forbidden.
4. Of all such other powers as the principal has by his direct act, negligent omission, or acquiescence, caused or permitted persons dealing with the agent reasonably to believe that the principal had conferred.
5. The powers the agent's exercise of which the principal has subsequently, with full knowledge of the facts, ratified and confirmed.

Letting the Contract

In the placing of all contracts for public works, and sometimes in private enterprises, contracts are let on the basis of open bidding. There are certain principles to be observed in doing this, and engineers should be familiar with the practices which have been fairly well established. The basic idea is to preserve conditions of exact equality of opportunity for those presenting their proposals, who are properly equipped for doing the work, and at the same time to insure the presentation of bids in such form and with such designated subdivisions as will make possible a comparison of the proposals on a proper basis.

Complete specifications form the true basis for the preparation of estimates of cost on which bids must be based. To avoid the expense of sending broadcast the bulky specifications, in an attempt to reach all who may desire to submit bids, abbreviated statements are prepared containing information which will enable constructors to determine whether or not they are interested. This brief statement is published conspicuously in the public press as an advertisement. The list of the items of information which it should contain carries in itself an explanation of the purposes to be served, so that extended discussion is unnecessary.

Points to Be Covered in the Advertisement

1. By whom bids will be received.
2. Where received.
3. When received.
4. Nature of work or material to be furnished.
5. Location of work.

6. Amount of work or material to be furnished.
7. When contract is to be begun and when finished.
8. Where plans may be seen or obtained.
9. Where specifications may be seen or obtained.
10. What security will be required with proposal. (If resident bondsmen are required, it should be stated.)
11. What bond will be required with contract. (If resident bondsmen are required, it should be stated.)
12. When proposals will be opened.
13. When contract will be awarded.
14. Other information of interest or importance to non-resident bidders.
15. From whom general information may be obtained.
16. Reservation of rights to reject any or all bids, or to waive informalities.
17. Official signature of officers letting work or receiving bids.

Instructions to Bidders

Supplementing the specifications there is usually a statement giving instructions to bidders on various matters not directly included in the specifications themselves. The list which follows shows the points usually covered and the order in which they may properly be arranged.

1. General notice, including time of receiving bids and general character of the work.
2. How sealed, and to whom delivered.
3. Formalities required in proposals.
4. Manner of stating prices.
5. Estimates.
6. Where information can be obtained.
7. Reservation to alter amounts of work.
8. Reservation as to amount of work let under single contract.
9. Reservations as to time of beginning and completion.
10. Reasons for rejection of bids.
11. Security to be required with bid and with contract.
12. Security with contract.
13. Miscellaneous requirements.

Form of Proposal

Careful attention should be given to the explanation of the form in which bids are to be made. This is essential to the making of a true comparison to determine the bid most favorable to the owner. There may be natural subdivisions on which separate quotations should be made. In purchase contracts it frequently is desirable to award these separate sections to different bidders. There may be special considerations under which the work is to be done or the material supplied. Whatever it may be, full instructions constitute the only safeguard to making a contract equitable to both parties, and it should be insisted that the bidders conform to all requirements in the way of furnishing detailed bids on the several sections.

The following illustrates the idea, although a single form cannot be made to cover the many variable stipulations appropriate to the multitude of types of contract work.

The formal statement usually includes:

1. "The bidder has carefully examined the location, plans and specifications," and

2. "The bid has been made without collusion or fraud." (These two declarations are commonly embodied in the proposal. They may have little legal significance, but serve as a warning.)

3. The agreed dates of beginning and completion.

4. Stating the character and amount of security submitted with the bid and agreeing to forfeit the same if the bid is accepted and the bidder fails to enter the contract as agreed.

5. An agreement to furnish security and a statement as to the character of the same.

6. The names of subcontractors, when parts of the work are to be sublet to other contractors or manufacturers, and, finally,

7. The signature of principals, their place of business, and the signature of witnesses or an acknowledgment if required.

PROPOSAL[1]

To the Board of Park Commissoners of the City of Boston for building abutments and wing-walls for a bridge at Wood Island Park, East Boston.

To the Board of Park Commissioners of the City of Boston for building abutments and wing-walls for a bridge at Wood Island Park, East Boston.

The undersigned hereby declares that he has carefully examined the annexed form of contract and specifications, and will provide all necessary machinery, tools, apparatus, and other means for construction, and do all the work, and furnish all the materials called for by said contract and specifications, in the manner prescribed by the contract and the specifications, and the requirements under them of the Engineer, for the sum of.........

.................................($.................)

.... .Accompanying this proposal is a certified check for the sum of

.................., as called for in the foregoing advertisement.

No member of the City Council, and no person in any office or employment of the City of Boston, is directly or indirectly interested in this proposal, or in any contract which may be made under it, or in expected profits to arise therefrom; and this proposal is made in good faith, without collusion or connection with any other person bidding for the same work.

Name..........................

Address.......................

When it is desired to have separate bids on subdivisions of the work, these subdivisions are listed in detail with blank spaces for filling in the amount

[1] See Mead's "Contracts and Specifications."

of the bid on each. This list of subdivisions is inserted in the space provided in the above form for the statement of the amount of the bid.

PREPARATION OF CONTRACTS

In a brief treatment of the subject, such as is given here, little can be done in the way of covering the complex task of writing construction contracts. The best that can be done is to furnish a few good samples which may be studied as the basis for agreements on similar work. When an enterprise involves any unusual features, the only safe course is to submit the matter to competent legal counsel. Governmental, state, and municipal agreements are commonly made on standard forms which have been developed by the legal departments. Contracts for the purchase of machinery are likewise drawn on lines standardized by the manufacturing companies.

During recent years efforts have been made to standardize government contracts. The first illustration given below is the result of coöperative study by the agencies noted. The second is the form used for machinery contracts by the Western Electric Company.

UNIVERSAL CONTRACT AGREEMENT

As Applied to Railroad Construction

This form is the outcome of conferences of representatives of the following bodies:

American Association of State Highway Officials.
American Institute of Architects.
American Railway Engineering Association.
American Society of Civil Engineers.
American Water Works Association.
Associated General Contractors of America.
Federated American Engineering Societies.
National Association of Builders' Exchanges.
Western Society of Engineers.

INTRODUCTION

Early in the proceedings of the Joint Conference on Standard Contract Forms, discussion centered upon the question of arbitration. This subject was found to be so intimately connected with numerous other provisions of the contract that the Conference was obliged to decide at the outset whether it would include an arbitration clause or reject the principle of arbitration altogether. After extended deliberation upon the matter, it was decided that an arbitration clause should be included; accordingly the clause submitted by the Drafting Committee, which is practically that of the American Institute of Architects, was incorporated in the documents.

The subject of arbitration proved to be such a complicated matter that it was not possible at this conference to draft a clause acceptable to all of the

representatives, but, in order that the principle itself might be included, leaving for further deliberation its proper application, the clause submitted was accepted. From criticism and suggestions, to be received by the Conference after the documents have been transmitted to the respective associations, it can doubtless formulate an acceptable contract provision. This explanation is made in order that no one may reject the whole principle of arbitration, on account of the manner in which it is applied in the accompanying form of agreement.

That some limitation of arbitration is necessary for successful and expeditious execution of construction was voiced by practically all members of the Conference, but an adequate expression of this limitation for employment in the standard documents was precluded by the limited duration of the meetings.

The first meeting of the Joint Conference on Standard Construction Contracts was held December 15, 1921, at the Department of Commerce, Washington, D. C. After a two-day session, opened by Mr. Hoover, a plan was adopted for drawing up a system of standard documents embodying the following forms:

a. A Universal Agreement for contracts between the owner and contractor containing those provisions of a general character applicable to any type of construction.

b. A set of general conditions for each division of construction, complementary to the Universal Agreement and containing those principles of a character applicable only to the individual type of work.

At the second meeting, held April 14, 1922, at the Department of Commerce, a form of Universal Agreement, with a set of Building General Conditions and set of Railroad General Conditions complementary thereto, was submitted by the Drafting Committee for consideration by the Conference. These documents, during two days' deliberation, were revised in accordance with views of the representatives, and were then approved by the Conference for transmittal to the respective associations for suggestions, these suggestions to be the basis for redrafting prior to adoption of the documents.

The two contract documents contained in this pamphlet are the Universal Agreement as applied to railroad work and a set of Railroad General Conditions. These two documents, together with the Plans and Specifications, constitute a railroad construction contract. Following these is presented a tabulation of items wherein these documents differ from those of the American Railway Engineering Association.

To facilitate comparing those documents with the Standard Documents of the American Institute of Architects and the American Railway Engineering Association, a set of symbols referring to those Documents is used as follows:

Any symbol placed on right hand side of the page designates where the subject matter above is found in the A. R. E. A. Contract, and any symbol placed on the left hand side designates where the subject matter above is found in the A. I. A. Contract.

The number in the symbol gives the number of the article referred to, the letter "A" signifies that the article is in the Agreement of the Contract referred to; the letter "G" signifies that the article is in

the General Conditions of the Contract referred to and the asterisk indicates that the subject matter above is not treated in the Contract referred to.

In the A. R. E. A. Contract, articles of the Agreement are not numbered and when one of these is referred to the letter "P" with a number designates a paragraph in that agreement, *e. g.*, P 2 refers to Par. 2 of the A. R. E. A. Agreement.

WARD P. CHRISTIE
Secretary.

NOTE: It has seemed wise to print in full the above statement of the conference in order that all may understand the exact conditions under which the Universal Agreement was developed. The form is subject to further revision, but it furnishes the best illustration extant of the deliberations directed toward the important task of establishing a uniform type of construction contract. The author here acknowledges his obligations to representatives of the conferees for the privilege of using the form.

THE UNIVERSAL AGREEMENT

THIS AGREEMENT made the . . . day of . . . .
in the year Nineteen Hundred and . . by and between

hereinafter called the Constructor, and . . . .
. . . .
. hereinafter called the Company
WITNESSETH, that the Constructor and the Company for the considerations hereinafter named agree as follows:

PART A*

ARTICLE I

Scope of Work

The Constructor shall perform all the work shown on the Drawings and described in the Specifications entitled . . . .

(Here insert the caption descriptive of the work as used in the Proposal, General Conditions, Specifications, and upon the Drawings)

prepared by. . . . .

acting as, and in these Contract Documents entitled the Chief Engineer, and shall do everything required by the General Conditions of the Contract, the Specifications and the Drawings.

A 1 P 2

*Part "A" contains those Articles in which blank spaces are to be filled out in preparing the individual contract, and

Part "B" contains those Articles which require no filling out of blanks for the individual contract.

ARTICLE II

Time of Completion

The work to be performed under this Contract shall be substantially completed...

(Here insert the date or dates of completion, commencement if desired, and stipulations as to liquidated damages if any)

....

....

A 2 P 3

ARTICLE III

The Contract Sum

The Company shall pay the Constructor for the performance of the Contract, subject to additions and deductions provided therein, a sum of money as follows:

....

....

(State here the lump sum amount, unit prices or both as desired in individual cases)

....

....

....

....

A 3 P 4

Where the quantities originally contemplated are so materially changed that the application of the agreed unit price to the quantity of work performed is shown to create a hardship to the owner or the Constructor, there shall be an equitable adjustment of the contract to prevent such hardship.

* 634 A

ARTICLE IV

Progress Payments

The Company shall make payments on account of the Contract as provided therein, as follows:

On or about the.............. day of each month ninety per cent of the value, proportionate to the amount of the Contract, of labor and materials incorporated in the work and of materials suitably stored at the site thereof up to the first day of that month as estimated by the Engineer, less the aggregate of previous payments.

(Insert here any provision to be made for limiting or reducing the amount retained after the work reaches a certain stage of completion)

....

....

....

....

A 3 G 36

ARTICLE V

Acceptance and Final Payment

The Engineer shall promptly make final inspection for acceptance upon receipt of written notice that the work is ready for such inspection, and shall, within..............days after the Constructor has fully completed

the work, make a final estimate of the work performed, and shall execute a certificate over his signature, stating that the work provided for in this contract has been completed and accepted by him under the terms and conditions thereof; and the entire balance found to be due the Constructor shall be payed to him within . . . . .days after he has fully performed all of his contractual obligations. These obligations shall include the submission of evidence satisfactory to the Chief Engineer that all pay rolls, material bills and other indebtedness connected with the work have been paid.

A 3 G 37

If when the work has been substantially completed, it should develop that full completion thereof is delayed through no fault of the Constructor, or if for any other reason the Chief Engineer deems it advisable, the Company shall, without terminating the contract, make payment in full for that portion of the work completed. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of claims.

A 3

ARTICLE VI

The Contract Documents

The General Conditions of the Contract, the Specifications and the Drawings, together with this Agreement, shall form the Contract, and they are as fully a part of the Contract as if hereto attached or herein repeated; the following is an enumeration of the Specifications and Drawings:

. . . .

. . . .

. . . .

A 4 P 2

PART B*

ARTICLE VII

Decisions of the Engineer

The Engineer shall, within a reasonable time, make decisions on all claims of the Constructor and on all other matters relating to the execution and progress of the work or the interpretation of the Contract Documents.

G 10 G 25, G 26

ARTICLE VIII

Inspection of Work

The Engineer and his representatives shall at all times have access to the work wherever it is in preparation or progress, and the Constructor shall provide proper facilities for such access and for inspection.

If the specifications, the Engineer's instructions, laws, ordinances or any public authority require any work to be specially tested or approved, the Constructor shall give the Engineer timely notice of its readiness for inspection, and if the inspection is by another authority than the Engineer, of the

date fixed for such inspection. Inspections by the Engineer shall be promptly made, and, where practicable, at the source of material supply. Inspection at the source shall not constitute acceptance of materials subsequently damaged.

If any such work should be covered up without approval or consent of the Engineer, it must, if required by the Engineer, be uncovered for examination at the Constructor's expense.

Re-examination of questioned work may be ordered by the Engineer. If such work be found in accordance with the contract, the Company shall pay the cost of re-examination and replacement. If such work be found not in accordance with the contract, the Constructor shall pay such cost, unless he shall show that the defect in the work was caused by another Constructor, and, in that event, the Company shall pay the cost.

G 13 G 12

ARTICLE IX

Correction of the Work Before Final Payment

The Constructor shall promptly remove from the premises all materials condemned by the Engineer as failing to conform to the Contract, whether incorporated in the work or not, and the Constructor shall promptly replace and re-execute his own work in accordance with the Contract and without expense to the Company and shall bear the expense of making good all work of other Constructors destroyed or damaged by such removal or replacement.

If the Constructor does not remove such condemned work and materials within a reasonable time, fixed by written notice, the Company may remove them and may store the material at the expense of the Constructor. If the Constructor does not pay the expense of such removal within reasonable time thereafter, the Company may, upon ten days' written notice, sell such materials at auction or at private sale and shall account for the net proceeds thereof, after deducting all the costs and expenses that should have been borne by the Constructor.

G 14 G 13

ARTICLE X

Deductions for Uncorrected Work

If the Chief Engineer deems it inexpedient to correct work injured or done not in accordance with the Contract, the difference in value together with a fair allowance for damage shall be deducted, the amount deducted to be determined by agreement or arbitration.

G 15 G 13

ARTICLE XI

Protection of Work and Property: Emergencies

The Constructor shall continuously maintain adequate protection of all his work from damage and shall protect the Company's property from injury arising in connection with this Contract. He shall make good any such damage or injury, except such as may be directly due to errors in the Con-

tract Documents or agents or employes of the Company. He shall adequately protect adjacent property as provided by law and the Contract Documents. He shall provide and maintain all passage ways, guard fences, lights and other facilities for protection necessitated by public authority and local conditions.

G 17 G 19, G 5

In an emergency affecting the safety of life or of the work or of adjoining property, the Constructor, without special instruction or authorization from the Engineer, is hereby permitted to act, at his discretion, to prevent such threatened loss or injury, and he shall so act, without appeal, if so instructed or authorized. Any claim for compensation on account of emergency work shall be passed upon by the Engineer.

G 18

ARTICLE XII

Changes in the Work

The Company, without invalidating the contract, may order extra work or make changes by altering, adding to or deducting from the work, the contract sum being adjusted accordingly. All such work shall be executed under the conditions of the original contract except that any claim for extension of time caused thereby shall be adjusted at the time of ordering such change.

In giving instructions the Engineer shall have authority to make minor changes in the work not involving extra cost and not inconsistent with the purposes of the work, but otherwise, except in an emergency endangering life or property, no extra work or change shall be made unless in pursuance of a written order by the Engineer, and no claim for an addition to the contract sum shall be valid unless so ordered.

The value of any such extra work or change shall be determined in one or more of the following ways:

a. By estimate and acceptance in a lump sum.
b. By unit prices named in the contract or subsequently agreed upon.
c. By cost and percentage or by cost and a fixed fee.
d. If none of the above methods is agreed upon, the Constructor, provided he receive an order as above, shall proceed with the work, no appeal to arbitration being allowed from such order to proceed.

In cases (c) and (d), the Constructor shall keep and present in such form as the Engineer may direct, a correct account of the net cost of labor and materials, together with vouchers. In any case, the Engineer shall certify to the amount due to the Constructor. Pending final determination of value, payments on account of changes shall be made on the Engineer's estimate.

G 2 G 24 G 28, G 29

ARTICLE XIII

Claims for Extra Cost

If the Constructor claims that any instructions by drawings or otherwise, involve extra cost under this contract, he shall give the Engineer written

notice thereof before proceeding to execute the work except in emergency endangering life or property, and, in any event, within two weeks of receiving such instructions, and the procedure shall then be as provided for in changes in the work. No such claim shall be valid unless so made.

G 25 G 29

ARTICLE XIV

Payments Withheld

The Company may withhold or, on account of subsequently discovered evidence, nullify the whole or a part of any estimate for payment to such extent as may be necessary to protect itself from loss on account of:

a. Defective work not remedied.
b. Claims filed or reasonable evidence indicating filing of claims.
c. Failure of the Constructor to make payments properly to subcontractors or for material or labor.
d. A reasonable doubt that the contract can be completed for the balance then unpaid.
e. Damage to another Constructor.

When all the above grounds are removed payment shall be made for amounts withheld because of them.

G 28 G 33-c, G 36

ARTICLE XV

Delays and Extension of Time

If the Constructor be delayed in the completion of the work by any act or neglect of the Company, or of its employes, or by any other Constructor employed by the Company, or by changes ordered in the work, or by strikes, lockouts, fire, unusual delay by common carriers, unavoidable casualties or any causes beyond the Constructor's control, or by delay authorized by the Chief Engineer pending arbitration, or by any cause which the Chief Engineer shall decide to justify the delay, then the time of completion shall be extended for such reasonable time as the Chief Engineer may decide will compensate for such delay.

No such extension shall be made for delay occurring more than seven days before claim therefor is made in writing to the Engineer. In the case of a continuing cause of delay, only one claim is necessary.

If no schedule or agreement, stating the dates upon which drawings shall be furnished, is made, then no claim for delay shall be allowed on account of failure to furnish drawings until two weeks after demand for such drawings and not then unless such claim be reasonable.

This article does not exclude the recovery of damages for delay by either party under other provisions in the contract documents.

G 35 G 31

ARTICLE XVI

The Company's Right to Do Work

If the Constructor should neglect to prosecute the work properly or fail to perform any provision of this contract, the Company, after three days'

written notice to the Constructor, may, without prejudice to any other remedy he may have, make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Constructor.

G 36 G 33-C

ARTICLE XVII

Company's Right to Terminate Contract

If the Constructor should be adjudged a bankrupt, or if he should make a general assignment for the benefit of his creditors, or if a receiver should be appointed on account of his insolvency, or if he should persistently or repeatedly refuse or should fail, except in cases for which extension of time is provided, to supply enough properly skilled workmen or proper materials, or if he should fail to make prompt payment to sub-contractors, or for material or labor, or persistently disregard laws, ordinances or the instructions of the Engineer, or otherwise be guilty of a substantial violation of any provision of the contract, then the Company, upon the certificate of the Chief Engineer that sufficient cause exists to justify such action, may, without prejudice to any other right or remedy and after giving the Constructor seven days' written notice terminate the employment of the Constructor and take possession of the premises and of all materials, tools and appliances thereon and finish the work by whatever method he may deem expedient. In such case the Constructor shall not be entitled to receive any further payment until the work is finished. If the unpaid balance of the contract sum shall exceed the expense of finishing the work, including compensation for additional managerial and administrative services, such excess shall be paid to the Constructor. If such expense shall exceed such unpaid balance, the Constructor shall pay the difference to the Company. The expense incurred by the Company as herein provided, and the damage incurred through the Constructor's default, shall be certified by the Chief Engineer.

G 37 G 33-B

ARTICLE XVIII

Constructor's Right to Stop Work or Terminate Contract

If the work should be stopped under an order of any court, or other public authority, for a period of three months, through no act or fault of the Constructor or of any one employed by him, or if the Engineer should fail to issue any estimate within seven days after it is due, or if the Company should fail to pay to the Constructor, within seven days of its maturity and presentation, any sum certified by the Engineer or awarded by the Arbitrators, then the Constructor may, upon three days' written notice to the Company and the Engineer, stop work or terminate this contract and recover from the Company payment for all work executed and any loss sustained upon any plant or material and reasonable profit and damages.

G 38 G 35

ARTICLE XIX

Damages

If either party to this contract should suffer damage in any manner because of any wrongful act or neglect of the other party or of any one employed by him, then he shall be reimbursed by the other party for such damage.

Claims under this clause shall be made in writing to the party liable within a reasonable time of the first observance of such damage and not later than the time of final payment, except as expressly stipulated otherwise in the case of faulty work or materials and shall be adjusted by agreement or arbitration.

G 39 G 15

ARTICLE XX

Assignment

Neither party to the contract shall assign the contract or sublet it as a whole without the written consent of the other, nor shall the Constructor assign any moneys due or to become due to him hereunder, without the previous written consent of the Chief Engineer.

G 42 G 7

ARTICLE XXI

Constructor's Liability Insurance

The Constructor shall maintain such insurance as will protect him from claims under workmen's compensation acts and from any other claims for damages for personal injury, including death, which may arise from operations under this contract, whether such operations be by himself or by any subcontractor or anyone directly or indirectly employed by either of them. Certificates of such insurance shall be filed with the Chief Engineer, if he so require, and shall be subject to his approval for adequacy of protection.

G 19 G 15

ARTICLE XXII

Liens

Neither the final payment nor any part of the retained percentage shall become due until the Constructor, if required, shall deliver to the Company a complete release of all liens arising out of this contract, or receipts in full in lieu thereof, and, if required in either case, an affidavit that so far as he has knowledge or information the releases and receipts include all the labor and material for which a lien could be filed; but the Constructor may, if any subcontractor refuses to furnish a release or receipt in full, furnish a bond satisfactory to the Company, to indemnify it against any lien. If any lien remain unsatisfied after all payments are made, the Constructor shall refund to the Company all moneys that the latter may be compelled to pay in discharging such lien, including all costs and a reasonable attorney's fee.

G 29 G 17

ARTICLE XXIII

Permits and Regulations

Permits and licenses of a temporary nature necessary for prosecution of the work shall be obtained and paid for by the Constructor. Permits, surveys and licenses for permanent structures or permanent changes in existing facilities shall be obtained and paid for by the Company.

The Constructor shall give all notices and comply with all laws, ordinances, rules and regulations bearing on the conduct of the work as drawn and specified. If the Constructor observes that the drawings and specifications are at variance therewith, he shall promptly notify the Engineer in writing, and any necessary changes shall be adjusted, as provided in the contract for changes in the work. If the Constructor performs any work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Engineer, he shall bear all costs arising therefrom.

G 30 G 4

ARTICLE XXIV

Royalties and Patents

The Constructor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save the Company harmless from loss on account thereof, except that the Company shall be responsible for all such loss when the product of a particular manufacturer or manufacturers is specified, but if the Constructor has information that the article specified is an infringement of a patent he shall be responsible for such loss unless he promptly gives such information to the Engineer.

G 31

ARTICLE XXV

Superintendence: Supervision

The Constructor shall keep on his work, during its progress, a competent superintendent and any necessary assistants, all satisfactory to the Engineer. The superintendent shall not be changed except with the consent of the Engineer unless the superintendent proves to be unsatisfactory to the Constructor and ceases to be in his employ. The superintendent shall represent the Constructor in his absence and all directions given to him shall be as binding as if given to the Constructor. Important directions shall be confirmed in writing to the Constructor. Other directions shall be so confirmed on written request in each case.

The Constructor shall give efficient supervision to the work, using his best skill and attention. He shall carefully study and compare all drawings, specifications and other instructions and shall at once report to the Engineer any error, inconsistency or omission which he may discover.

G 11 G 8

ARTICLE XXVI

Arbitration

All questions in dispute under this contract shall be submitted to arbitration at the choice of either party to the dispute.

The Constructor shall not cause a delay of the work on account of any arbitration proceedings, except by agreement with the Chief Engineer.

The demand for arbitration shall be filed in writing with the Chief Engineer in the case of an appeal from his decision, within ten days of its receipt and in any other case within a reasonable time after cause thereof and in no case later than the time of final payment, except as otherwise expressly stipulated in the contract. If the Engineer fails to make a decision within a reasonable time, an appeal to arbitration may be taken as if his decision had been rendered against the party appealing.

No one shall be nominated or act as an arbitrator who is in any way financially interested in this contract or in the business affairs of either the Company or the Constructor.

The general procedure shall conform to the laws of the State in which the work is to be erected. Unless otherwise provided by such laws, the parties may agree upon one arbitrator; otherwise there shall be three, one named, in writing, by each party to this contract, to the other party and to the Chief Engineer, and the third chosen by these two arbitrators, or if they fail to select a third within ten days, then he shall be chosen by the presiding officer of the Bar Association nearest to the location of the work. Should the party demanding arbitration fail to name an arbitrator within ten days of his demand, his right to arbitration shall lapse. Should the other party fail to choose an arbitrator within said ten days, then such presiding officer shall appoint such arbitrator. Should either party refuse or neglect to supply the arbitrators with any papers or information demanded in writing, the arbitrators are empowered by both parties to proceed ex parte.

The arbitrators shall act with promptness. If there be one arbitrator, his decision shall be binding; if three, the decision of any two shall be binding. Such decision shall be a condition precedent to any right of legal action, and wherever permitted by law it may be filed in Court to carry it into effect.

The arbitrators, if they deem that the case demands it, are authorized to award to the party whose contention is sustained such sums as they shall deem proper for the time, expense and trouble incident to the appeal, and if the appeal was taken without reasonable cause, damages for delay. The arbitrators shall fix their own compensation, unless otherwise provided by agreement, and shall assess the costs and charges of the arbitration upon either or both parties.

The award of the arbitrators must be in writing and, if in writing, it shall not be open to objection on account of the form of the proceedings or the award, unless otherwise provided by the laws of the State in which the work is to be erected.

In the event of such laws providing on any matter covered by this article otherwise than as hereinbefore specified, the method of procedure throughout and the legal effect of the award shall be wholly in accordance with the

said State laws, it being intended hereby to lay down a principle of action to be followed, leaving its local applications to be adapted to the legal requirements of the place in which the work is to be erected.
G 45

ARTICLE XXVII

Execution, Correlation and Intent of Documents

The Contract Documents shall be signed in duplicate by the Company and Constructor. In case of failure to sign the General Conditions, Drawings or Specifications the Engineer shall identify them.

The Contract Documents are complementary, and what is called for by anyone shall be as binding as if called for by all. The intention of the documents is to include all labor and materials, equipment and transportation reasonably necessary for the proper execution of the work. It is not intended, however, that materials or work not covered by or properly inferable from any heading, branch, class or trade of the specifications shall be supplied unless distinctly so noted on the drawings. Materials or work described in words which so applied have a well known-technical or trade meaning shall be held to refer to such recognized standards.
G 2 G 3

The Constructor and the Company for themselves, their successors, executors, administrators and assigns, hereby agree to the full performance of the covenants herein contained.

IN WITNESS WHEREOF they have executed this agreement, the day and year first above written.

Standard General Conditions —Railroads

SECTION 1—Principles and Definitions

a The Contract Documents consist of the Agreement, the General Conditions of the Contract, the Drawings and Specifications, including all modifications thereof incorporated in the documents before their execution. These form the Contract.
G 1 P 1

b. The Company, the Constructor, the Engineer and the Chief Engineer are those named as such in the Agreement. The last three are treated throughout the Contract Documents as if each were of the singular number and masculine gender.
G 1 *

c. Wherever in this Contract the word Engineer is used, it shall be understood as referring to the Chief Engineer of the Company, acting personally or through an assistant duly authorized in writing for such act by the Chief Engineer, and wherever the words Chief Engineer are used it shall be understood as referring to the Chief Engineer in person, and not to any assistant engineer.
G 24

d. The term subcontractor, as employed herein, includes only those having a direct contract with the Constructor and it includes one who furnishes material worked to a special design according to the plans or specifications of this work, but does not include one who merely furnishes material not so worked.
G 1 *

e. The term "work" of the Constructor or Subcontractor includes labor or materials or both, equipment, transportation, or other facilities necessary to complete the contract.
G 1 *

f. All time limits stated in the Contract Documents are of the essence of the contract.
G 1 P2

g. The law of the place of building shall govern the construction of this contract.
G 1 *

h. No work shall be done at night without the previous approval of the Engineer.
* G 12

SECTION 2—Constructor's Understanding

It is understood and agreed that the Constructor has, by careful examination, satisfied himself as to the nature and location of the work, the conformation of the ground, the character, quality and quantity of the materials to be encountered, the character of equipment and facilities needed preliminary to and during the prosecution of the work, the general and local conditions, and all other matters which can in any way affect the work under this contract. No verbal agreement or conversation with any officer, agent or employee of the Company, either before or after the execution of this contract, shall affect or modify any of the terms or obligations herein contained.
* G 2

SECTION 3—Drawings

a. *Copies Furnished*—Unless otherwise provided in the Contract Documents the Engineer will furnish to the Constructor, free of charge, all copies of drawings and specifications reasonably necessary for the execution of the work.
G 4 *

b. *Detail Drawings and Instructions*—The Engineer shall furnish, with reasonable promptness, additional instructions, by means of drawings or otherwise, necessary for the proper execution of the work. All such drawings and instructions shall be consistent with the Contract Documents, true developments thereof, and reasonably inferable therefrom.
G 3 *

c. *Copies of the Work*—The Constructor shall keep one copy of all drawings and specifications on the work, in good order, available to the Engineer and to his representatives.
G 6 *

SECTION 4—Materials, Appliances, Transportation

Unless otherwise stipulated, the Constructor shall provide and pay for all materials, labor, water, tools, equipment, light, power and transportation and other facilities necessary for the execution and completion of the work.

G 12 P 1

SECTION 5—Property and Right of Entry

The Company shall provide the lands upon which the work under this contract is to be done, except that the Constructor shall provide land required for the erection of temporary construction facilities and storage of his material, together with right of access to same.

The Constructor shall not ship any material or equipment until he has received written notice from the Engineer that he may proceed with said work or any part thereof.

G 32 G 30

SECTION 6—Notice—How Served

Any notice to be given by the Company to the Constructor under this contract shall be deemed to be served if the same be delivered to the man in charge of any office used by the Constructor, or to his foreman or agent at or near the work, or deposited in the postoffice, postpaid, addressed to the Constructor at his last known place of business.

G 1 G 34-b

SECTION 7—Rights of Various Interests

Wherever work being done by Company forces or by other Constructors is contiguous to work covered by this contract the respective rights of the various interests involved shall be established by the Engineer, to secure the completion of the various portions of the work in general harmony.

G 45 G 6

SECTION 8—Timely Demand for Points and Instructions

The Constructor shall provide reasonable and necessary opportunities and facilities for setting points and making measurements. He shall not proceed until he has made timely demand upon the Engineer for, and has received from him, such points and instructions as may be necessary as the work progresses. The work shall be done in strict conformity with such points and instructions.

G 3 G 9

SECTION 9—Staking the Work

The Constructor shall give the Engineer reasonable notice of starting new work and shall provide him with any assistance required in staking or measuring the work.

SECTION 10—Preservation of Stakes

The Constructor shall carefully preserve bench marks, reference points and stakes, and in case of willful or careless destruction, he shall be charged with the resulting expense and shall be responsible for any mistakes that may be caused by their unnecessary loss or disturbance.

* G 11

SECTION 11—Reporting Errors and Discrepancies

If the Constructor, in the course of the work, finds any discrepancy between the plans and the physical conditions of the locality, or any errors or omissions in plans or in the layout as given by said points and instructions, it shall be his duty to immediately inform the Engineer, in writing, and the Engineer shall promptly verify the same. Any work done after such discovery, until authorized, will be done at the Constructor's risk.

G 30 G 10

SECTION 12—Order and Discipline

The Contractor shall at all times enforce strict discipline and good order among his employees, and any employee of the Constructor who shall be incompetent, disorderly or intemperate, or in any other way disqualified for or unfaithful to the work entrusted to him, shall be discharged immediately on the request of the Engineer, and he shall not again be employed on the work without the Engineer's written consent.

G 12 G 20

SECTION 13—Intoxicating Liquors and Drugs Prohibited

The Constructor, in so far as his authority extends, shall not permit the sale, distribution or use of any intoxicating liquors or drugs upon or adjacent to the work, or allow any such to be brought upon, to or near the property of the Company.

* G 22

SECTON 14—Hiring Company Employees

The Constructor shall not employ or hire any of the Company's employees without the permission of the Engineer.

* G 21

SECTION 15—Settlement for Wages

Whenever, in the opinion of the Chief Engineer, it may be necessary for the progress of the work to secure to any of the employees engaged in the work under this contract any wages which may then be due them, the Company is hereby authorized to pay said employees the amount due them or any lesser amount, and the amount so paid them, as shown by their receipts shall be deducted from any moneys that may be or become payable to said contractor.

G 28-C G 16

SECTION 16—Fire Insurance

The Constructor shall secure in the name of the Company, policies of fire insurance in amount, form and companies, satisfactory to the Chief Engineer, upon such structures and material as shall be specified by the latter, payable to the Company for the benefit of the Constructor or the Company as the Chief Engineer shall find their interests to appear.

G 21 G 14

SECTION 17—Work Adjacent to Railroad

Wherever the work embraced in this contract is near the tracks, structures or buildings of this Company or of other railroads, the Constructor shall use proper care and vigilance to avoid injury to persons or property. The work must be so conducted as not to interfere with the movement of trains

or other operations of the railroad; or, if in any case, such interference be necessary, the Constructor shall not proceed until he has first obtained specific authority and directions therefor from the proper designated officer of the Company and has the approval of the Engineer.

* G 18

SECTION 18—Bond

The Constructor shall, at the time of the execution and delivery of this contract and before the taking effect of the same, furnish and deliver to the company a written bond of indemnity to the amount of ——— dollars, in form and substance and with surety thereon satisfactory and acceptable to the Company, to insure the faithful performance, by the Constructor, of all the covenants and agreements on the part of the Constructor contained in this contract. This bond shall remain in force and effect for the full amount or such smaller sum as may at any time be specified by the Chief Engineer.

G 22 G 1

SECTION 19—Status of the Engineer

The Engineer shall have general supervision and direction of the work. He has authority to stop the work whenever such stoppage may be necessary to insure the proper execution of the Contract. He shall also have authority to reject all work and materials which do not conform to the contract; to direct the application of forces to any portion of the work, as in his judgment is required, and to order the force increased or diminished, and to decide questions which arise in the execution of the work.

G 9 G 25

SECTION 20—Order of Completion; Use of Completed Portions

The Constructor shall complete any portion or portions of the work in such order of time as the Engineer may require. The Company shall have the right to take possession of and use any completed or partially completed portions of the work, notwithstanding the time for completing the entire work or such portions may not have expired; but such taking possession and use shall not be deemed an acceptance of the work so taken or used or any part thereof. If such prior use increases the cost of or delays the work, the Constructor shall be entitled to such extra compensation, or extension of time, or both, as the Chief Engineer may determine.

* G 27

SECTION 21—Suspension of Work

The Company may at any time stop the work, or any part thereof, by giving......... day's notice to the Constructor in writing. The work shall be resumed by the Constructor within ten (10) days after the date fixed in the written notice from the Company to the Constructor so to do. The Company shall not be held liable for any damages or anticipated profits on account of the work being stopped, or for any work done during the interval of suspension. It will, however, pay the Constructor for expense of men and teams necessarily retained during the interval of suspension, provided the Constructor can show that it was not reasonably practicable to move these men and teams to other points at which they could have been employed. The Company will further pay the Constructor for time necessarily lost

during such suspension at the rate of ....% per annum on the estimated value of materials, equipment and fixtures furnished by the Constructor on the work which are necessarily idle during such suspension, said rate being understood to include depreciation, interest and insurance. But if the work, or any part thereof, shall be stopped by the notice in writing aforesaid, and if the Company does not give notice in writing to the Constructor to resume work at a date within..........of the date fixed in the writter notice to suspend, then the Constructor may abandon that portion of the work so suspended and he will be entitled to the estimates and payments for all such work done on the portions so abandoned, if any.

* G 32

SECTION 22—Annulment without Fault of Constructor

The Company shall have the right at any time, for reasons which appear good to it, to annul this contract upon giving thirty days' notice in writing to the Constructor, in which event the Constructor shall be entitled to the full amount of the estimate up to the time of such annulment, including the retained percentage. The Constructor shall be reimbursed by the Company for such expenditures as in the judgment of the Chief Engineer are not otherwise compensated for, and as are required in preparing for and moving to and from the work; the intent being that an equitable settlement shall be made with the Constructor.

* G 34-A

SECTION 23—Removal of Equipment

In the case of annulment of this contract before completion from any cause whatever, the Constructor, if notified to do so by the Company, shall promptly remove any part or all of his equipment and supplies from the property of the Company, failing which the Company shall have the right to remove such equipment and supplies at the expense of the Constructor.

* G 34-C

SECTION 24—Monthly Estimate

So long as the work herein contracted for is prosecuted in accordance with the provisions of this contract, and with such progress as may be satisfactory to the Chief Engineer, the said Chief Engineer will on or about the first day of each month, make an approximate estimate of the proportionate value of the work done and of material furnished or delivered upon the Company's property at the site of the work, up to and including the last day of the previous month. The amount of said estimate, after deducting ....% and all previous payments, shall be due and payable to the Contractor at the office of the Treasurer of the Company on or about the.................................day of the current month.

* G 36

SECTION 25—Subcontracts

The Constructor shall, as soon as practicable after the signature of the contract, notify the Chief Engineer in writing of the names of subcontractors proposed for the work and shall not employ any that the Chief Engineer may within a reasonable time object to as incompetent or unfit.

The Constructor agrees that he is as fully responsible to the Company for the acts and omissions of his subcontractors and of persons either directly or indirectly employed by them, as he is for the acts and omissions of persons directly employed by him.

Nothing contained in the contract documents shall create any contractual relation between any subcontractor and the Company.

G 43 G 7

SECTION 26—Indemnity

The Contractor shall indemnify and save harmless the Company from and against all losses and all claims, demands, payments, suits, actions, recoveries and judgments of every nature and description brought or recovered against it, by reason of any act or omission of the said Contractor, his agents or employees, in the execution of the work in consequence of any negligence or carelessness in guarding the same.

G 33 G 15

SECTION 27 —Cleaning Up

The Constructor shall, as directed by the Engineer, remove from the Company's property and from all public and private property, at his own expense, all temporary structures, rubbish and waste materials resulting from his operations. G 23

G 39

MACHINERY SALE CONTRACT

(Form used by the Western Electric Co.)

PROPOSAL

Dated

The Company, hereinafter called the Company, Submits for consideration the following proposal for Electrical Apparatus to .

,

hereinafter called the Purchaser. When this proposal is accepted and signed in duplicate by the Purchaser and countersigned at . . .,
by an officer of the Company, or a manager thereof, it shall become a contract and constitute an agreement between the parties hereto.

The Company agrees to furnish the Purchaser under this proposal the apparatus hereinafter mentioned, and agrees to perform all work in accordance with the attached . . . . . pages of specifications, which together with the guarantees and special agreements mentioned in the specifications, are made a part hereof.

All previous communications, either verbal or written, with reference to the subject matter of this agreement are hereby withdrawn and annulled, and this proposal or contract shall be modified only by a duly approved supplementary agreement.

List of Apparatus to be Furnished:

Price. In consideration of the above-mentioned apparatus furnished under the provisions herein made, the Purchaser agrees to pay the Company the sum of

. Dollars ($

Terms. The above amount specified is not subject to cash discount and is to be paid at the office of the Company, located at

in the following manner

All payments above provided for shall bear interest at the rate of 6 % per annum after they become due. All cash shall be paid in New York or Chicago exchange

If shipment of apparatus herein specified, or any part thereof, is delayed by any cause for which the purchaser is directly or indirectly responsible, the date of completion of said apparatus by the Company shall be regarded as the date of shipment in determining when payments for said apparatus are to be made. If all the apparatus should not be forwarded on the same date, pro rata payments shall be made for partial payments.

Delivery. The Company agrees to ship said apparatus

days after the date of the acceptance of this contract by the Company, or as near to this date as its shop conditions will allow, the shop conditions at the time of execution of this contract being such as to give the Company reasonable assurance that the above specified delivery date can be met. The time of delivery is dependent upon the promptness of the Purchaser in furnishing all information the Company may deem necessary regarding details which are to be determined by the Purchaser. The Company shall not be held liable for delay caused by fire, strikes, riots, or any other cause beyond its control

Infringement of Patents The Company agrees that it will, at its own cost, defend any suits that may be instituted by any party against the Purchaser for alleged infringement of patents, when such alleged infringement shall relate to the apparatus furnished under this proposal and for which the Purchaser shall have made all payments then due, provided that immediate notice of the institution of such suits be given by the purchaser to the Company, and that the Purchaser shall permit the Company, through its counsel, to defend the same, and shall give the Company all needed information, assistance, and authority to enable it to do so, and in case of a final award of damages in such suits the Company shall pay such awards, but it shall not be responsible for any compromise made without its written consent, nor shall it be bound to defend any suits or to pay any damages therein when the same shall arise by the reason of the use of parts not furnished by the Company under this proposal.

Title to Property. The title and right of possession to the apparatus herein specified remains in the Company until all payments hereunder (including deferred payments and any notes or renewals thereof, if any) shall have been

fully made in cash, and it is agreed the said apparatus shall remain the personal property of the Company whatever may be the mode of its attachments to the realty or otherwise, until fully paid for in cash. Upon failure to make payments, or any of them, as herein specified, the Company may retain any and all partial payments which have been made, as liquidated damages, and shall be entitled to take immediate possession of said property, and be free to enter the premises where said apparatus may be located, and to remove the same as its property without prejudice to any further claims on account of damage which the Company may suffer from any cause.

Protection to Property. The purchaser agrees to reimburse the Company for all loss and expense to it resulting from damages to or destruction of said property through any cause other than the Company's fault, subsequent to such delivery.

Inspection. The expense of all inspections or tests of the property furnished under the terms hereof, other than the usual inspection and test made in the shops of the Company, shall be borne by the Purchaser, unless otherwise specified herein.

Installation. All apparatus covered by this proposal shall be installed by and at the expense of the Purchaser, unless otherwise specified herein.

Should the Purchaser desire the services of expert installers to superintend the erection of the apparatus covered by this proposal, the sum of \$. . . . per day, plus traveling and hotel expenses, is to be paid by the Purchaser for each expert for the time he is away from the Company's works.

If the Company is to deliver and erect the apparatus covered by this proposal, the Purchaser agrees to furnish, without charge, sufficient openings of proper size to get the apparatus to foundations, all necessary storage, rights of way, permits, and authority for the installation of the apparatus herein provided for, and to reimburse the Company for any losses incurred by reason of delay in starting the plant and completing the work that are not chargeable to the Company.

The Company agrees that the installation, if made by it, shall be done in a thorough and workman-like manner.

Unless otherwise expressly stipulated, it is understood that all wiring will be furnished, installed, and completed by the Purchaser. Terminal lugs on connection boards are to be furnished by the Company.

Guaranty. The Company guarantees the material used in the construction of the apparatus covered by this proposal to be of the best kind and quality suitable for the purpose. It guarantees that the workmanship and finish will be of the highest class and that the apparatus will be capable of operating as guaranteed, and agrees to correct at any time within a period of one year after delivery, any defects that may develop in material or workmanship, provided the Purchaser gives the Company immediate written notice of such defects; and provided further, that during said period the apparatus shall not be taxed beyond the rated capacity, shall be regularly cleaned and cared for, and in other respects shall be operated in a normal and proper manner.

The Company shall not be held responsible for work done, apparatus furnished, or repairs made by others.

Expiration of Proposition. This proposal is void unless accepted and returned on or before . '

Respectfully submitted,

.. . Company

Accepted: By ..

By . . . . .

Countersigned at this day of

. . . .

Company

By

APPENDIX B

ILLUSTRATIVE FORMS IN COMPANY ORGANIZATION

CERTIFICATE OF INCORPORATION OF THE COMPANY[1]

We, the undersigned, for the purpose of forming a corporation under and by virtue of the provisions of an act of the Legislature of the State of New Jersey, entitled "An Act concerning corporations (Revision of 1896)," and the several supplements thereto and acts amendatory thereof, do hereby severally subscribe for and agree to take the number of shares of stock of the said corporation hereinafter placed opposite our respective names, and do further certify and set forth as follows:

First. The name of said corporation shall be . ... Company

Second. The location of its principal office in the State of New Jersey shall be at No. 15 Exchange Place, Jersey City.

The name of the agent who shall be therein and in charge thereof, upon whom process against this corporation may be served, is the Corporation Trust Company of New Jersey.

Third. The objects for which this corporation is formed are:

a. To manufacture, prepare, compound, mix, combine, buy, sell and generally deal in all manner of chemicals, chemical products, drugs and pharmaceutical compounds, and preparations, and to patent, register or otherwise protect the same.

b. To obtain, purchase or otherwise acquire formula, patents and secret processes for the manufacture and preparation of chemicals, drugs and the compounds and preparations thereof, and to operate under, sell, assign, grant licenses in respect of, or otherwise turn the same to account.

c. To enter into, carry out or otherwise turn to account contracts of every kind, to have and maintain offices within and without the State, to acquire, hold, mortgage, lease and convey or otherwise use or dispose of real and personal property in any part of the world; and, in general, to carry on such operations and enterprises and to do all such things in connection therewith as may be permitted by the laws of New Jersey and be necessary or convenient in the conduct of the company's business.

Fourth. The total authorized stock of the corporation shall be twenty-five thousand dollars ($25,000), divided into two hundred and fifty (250) shares of the par value of one hundred dollars ($100) each, and the amount of capital stock with which said corporation will begin business is five thousand dollars ($5,000).

[1] A sample corporation charter, as published in Lough's "Corporation Finance," originally from Conyngton's "The Modern Corporation."

Fifth. The names and postoffice addresses of the incorporators and the number of shares subscribed for by each are as follows:

Name	Address	Shares
Willis J. Carhart,	15 Exchange Place, Jersey City, N. J.	40
Sheldon McCammus,	15 Exchange Place, Jersey City, N. J.	5
John B. Whelan,	15 Exchange Place, Jersey City, N. J	5

Sixth. The period of existence of said corporation shall be unlimited.

In Witness Whereof, we have hereunto set our hands and seals this 21st day of July, A. D., nineteen hundred and eight

Willis J. Carhart (L. S.)
Sheldon McCammus (L. S.)
John B Whelan (L. S.)

In the presence of
Harmon Watson
Thomas O'Connell
(Executed in due form)

BY-LAWS OF THE COMPANY[1]

NEW YORK CITY

ARTICLE I.—Stock

1. Certificates of Stock shall be issued in numerical order from the stock certificate book, be signed by the President and Treasurer and sealed by the Secretary with the corporate seal. A record of each certificate issued shall be kept on the stub thereof

2. Transfers of Stock shall be made only upon the books of the Company and before a new certificate is issued the old certificate must be surrendered for cancellation. The stock books of the Company shall be closed for transfers twenty days before general elections and ten days before dividend days.

3. The Treasury Stock of the Company shall consist of such issued and outstanding stock of the Company as may be donated to the Company or otherwise acquired, and shall be held subject to disposal by the Board of Directors. Such stock shall neither vote nor participate in dividends while held by the Company.

ARTICLE II.—Stockholders

1. The Annual Meeting of the stockholders of this Company shall be held in the principal office of the Company in New York City at 12 M. on the second Monday in January of each year, if not a legal holiday, but if a legal holiday, then on the day following.

2. Special Meetings of the stockholders may be called at the principal office of the Company at any time by resolution of the Board of Directors, or upon written request of stockholders holding one-third of the outstanding stock.

[1] A sample by-laws from the same source as the above.

3. Notice of Meetings, written or printed, for every regular or special meeting of the stockholders, shall be prepared and mailed to the last known postoffice address of each stockholder not less than ten days before any such meeting, and, if for a special meeting, such notice shall state the object or objects thereof. No failure or irregularity of notice of any regular meeting shall invalidate such meeting or any proceeding thereat.

4. A Quorum at any meeting of the stockholders shall consist of a majority of the voting stock of the Company, represented in person or by proxy. A majority of such quorum shall decide any question that may come before the meeting.

5. The election of Directors shall be held at the annual meeting of stockholders and shall, after the first election, be conducted by two inspectors of election, appointed by the President for that purpose. The election shall be by ballot, and each stockholder of record shall be entitled to cast one vote for each share of stock held by him.

6. The Order of Business at the annual meeting, and, as far as possible, at all other meetings of the stockholders, shall be:

1. Calling of roll.
2. Proof of due notice of meeting
3. Reading and disposal of any unapproved minutes.
4. Annual reports of officers and committees.
5. Election of directors.
6. Unfinished business.
7. New business
8. Adjournment

Article III.—Directors

1. The Business and Property of the Company shall be managed by a Board of seven Directors, who shall be stockholders and who shall be elected annually by ballot by the stockholders for the term of one year, and who shall serve until the election and acceptance of their duly qualified successors. Any vacancies may be filled by the Board for the unexpired term. Directors shall receive no compensation for their services.

2. The Regular Meetings of the Board of Directors shall be held in the principal office of the Company in New York City at 3 P.M., on the third Tuesday of each month, if not a legal holiday, but if a legal holiday, then on the day following.

3. Special Meetings of the Board of Directors to be held in the principal office of the Company in New York City may be called at any time by the President, or by any three members of the Board, or may be held at any time and place, without notice, by unanimous written consent of all the members, or with the presence of all members at such meetings.

4. Notices of both regular and special meetings shall be mailed by the Secretary to each member of the Board not less than five days before any such meeting, and notices of special meetings shall state the purpose thereof. No failure or irregularity of notice of any regular meeting shall invalidate such meeting or any proceeding thereat.

5. A Quorum at any meeting shall consist of a majority of the entire membership of the Board. A majority of such quorum shall decide any question that may come before the meeting.

6. Officers of the Company shall be elected by ballot by the Board of Directors at their first meeting after the election of Directors each year. If any office becomes vacant during the year, the Board of Directors shall fill the same unexpired term. The Board of Directors shall fix the compensation of the officers and agents of the Company.

7. The order of business at any regular or special meeting of the Board of Directors shall be:

1. Reading and disposal of any unapproved minutes.
2. Reports of officers and committees.
3. Unfinished business.
4. New business.
5. Adjournment.

Article IV.—Officers

1. The Officers of the Company shall be a President, a Vice President, a Secretary and a Treasurer, who shall be elected for one year and shall hold office until their successors are elected and qualify. The positions of Secretary and Treasurer may be united in one person.

2. The President shall preside at all meetings, shall have general supervision of the affairs of the Company, shall sign or countersign all certificates, contracts and other instruments of the Company as authorized by the Board of Directors; shall make reports to the directors and stockholders and perform all such other duties as are incident to his office or are properly required of him by the Board of Directors. In the absence or disability of the President, the Vice President shall exercise all his functions.

3. The Secretary shall issue notices for all meetings, shall keep their minutes, shall have charge of the seal and the corporate books, shall sign with the President such instruments as require such signature, and shall make such reports and perform such other duties as are incident to his office, or are properly required of him by the Board of Directors.

4. The Treasurer shall have the custody of all moneys and securities of the Company and shall keep regular books of account and balance the same each month. He shall sign or countersign such instruments as require his signature, shall perform all duties incident to his office or that are properly required of him by the Board, and shall give bond for the faithful performance of his duties in such sum and with such sureties as may be required by the Board of Directors.

Article V.—Dividends and Finance

1. Dividends shall be declared only from the surplus profits at such times as the Board of Directors shall direct, and no dividend shall be declared that will impair the capital of the Company.

2. The moneys of the Company shall be deposited in the name of the Company in such bank or trust company as the Board of Directors shall

designate, and shall be drawn out only by check signed by the Treasurer and countersigned by the President.

Article VI.—Seal

1. The Corporate Seal of the Company shall consist of two concentric circles, between which is the name of the Company, and in the center shall be inscribed, "Incorporated 1905, New York," and such seal, as impressed on the margin hereof, is hereby adopted as the Corporate Seal of the Company.

Article VII.—Amendments

1. These by-laws may be amended, repealed or altered, in whole or in part, by a majority vote of the entire outstanding stock of the Company, at any regular meeting of the stockholders, or at any special meeting where such action has been announced in the call and notice of such meeting.

2. The Board of Directors may adopt additional by-laws in harmony therewith, but shall not alter nor repeal any by-laws adopted by the stockholders of the Company.

ARTICLES OF CO-PARTNERSHIP[1]

Articles of Co-partnership, made this first day of June in the year One Thousand, Nine Hundred and Ten, by and between William H. Hull and Edward T. Moran, both of Borough of Brooklyn, City of New York.

Witnesseth:

That the said parties have mutually agreed and hereby do mutually agree to continue a co-partnership heretofore entered into by and between them and carried on at Nos. 712–724 Bedford Avenue, in the City of New York, Borough of Brooklyn, for the manufacture of carriages, under the firm name and style of Hull & Moran, upon the following terms and conditions:

First:

Said co-partnership shall continue until the same shall be dissolved by the mutual consent of the parties hereto, or ended in pursuance of some of the provisions hereinafter contained.

Second:

Each partner may terminate the co-partnership by giving thirty (30) days written notice to the other partner of his intention so to do.

Third:

The co-partnership shall be dissolved by the death of one of the partners; and in that case the surviving partner shall liquidate the business and pay over to the legal representatives of the deceased partner within six months or sooner, the interest of such deceased partner in said business.

[1] Sample partnership articles, from Gerstenberg and Hughes' "Commercial Law."

FOURTH:

All losses and profits shall be shared equally.

FIFTH:

The business shall be carried on under the firm name and title of Hull & Moran.

SIXTH:

In case the co-partnership be dissolved during the lifetime of both partners, then and in that case, both partners shall act as liquidating partners for the purpose of winding up the business.

SEVENTH:

In case of the death of one of the partners, the legal representatives of that partner shall have the right during business hours, to inspect the books of the firm, and to make an inventory, at their own proper expense, and the surviving partner shall assist them in every way possible by giving them all necessary information for the purpose of ascertaining the exact standing of the firm at the time of the death of such deceased partner.

EIGHTH:

The assets, which are to constitute the working capital of the firm, shall be contributed equally by the partners and said assets shall be the present business assets of said firm, which shall be taken over and be subject to this agreement.

NINTH:

Each partner shall be entitled to draw a salary of sixty dollars ($60.00) per week.

TENTH:

It is further agreed that a certain note bearing even date with these presents and made by said Edward T. Moran to the order of said William H. Hull, amounting to One Thousand Dollars, said be paid out of the surplus earnings of said Moran in said business, over and above the said salary of $60.00 per week to be paid to him; and all such surplus earnings shall be applied in payment or in part payment of said note and interest; and in case of a dissolution of said firm, the share of said Moran in the undivided profits and assets thereof, shall first be applied in payment of said note, and the interest of said Moran in said firm shall constitute the security for said note; and said Hull shall at all times have a lien upon the interest of said Moran in said firm to the extent of the unpaid portion of said note; and a transfer or assignment of the interest of said Moran in said firm shall be subject to such security and lien.

Eleventh:

Both partners shall give all their time and attention to the prosecution of said business and the affairs of said firm and shall not engage in any other business, and shall not make any accommodation notes or become accommodation endorsers, or become surety on any bond or undertaking, or embark in any speculation, without the consent of the other partner.

Twelfth:

True, full and accurate books of account shall be kept by the firm of all dealings and transactions by it, and shall be accessible and open to the inspection and examination of both partners at all times.

Thirteenth:

Neither party shall loan or use the funds or the credit of the firm, or the firm's name, for any purpose whatsoever, excepting only the business of the co-partnership.

Fourteenth:

All business operations, contracts, bargains, agreements, purchases, sales and other transactions relating to the co-partnership business, shall be the subject of mutual consultation, advice and agreement.

IN WITNESS WHEREOF, the parties hereto have hereunto set their respective hands and seals the day and year first above written.

William H. Hull.
Edward T. Moran.

In presence of
Edith Reardon.

State of New York, County of New York, ss..

On this first day of June, 1910, before me personally came William H. Hull and Edward T. Moran, both to me personally known and known to me to be the same individuals described in and who executed the foregoing instrument, and they severally duly acknowledged to me that they had executed the same.

Charles E. Norlin,
Commissioner of Deeds,
New York City.

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